Alvarion BreezeNET B300

WANFleX OS User Manual

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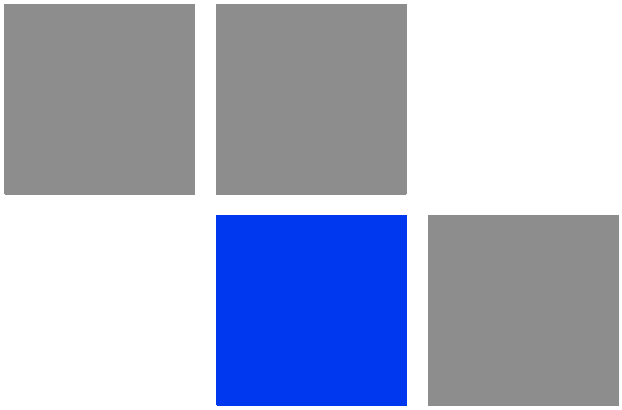
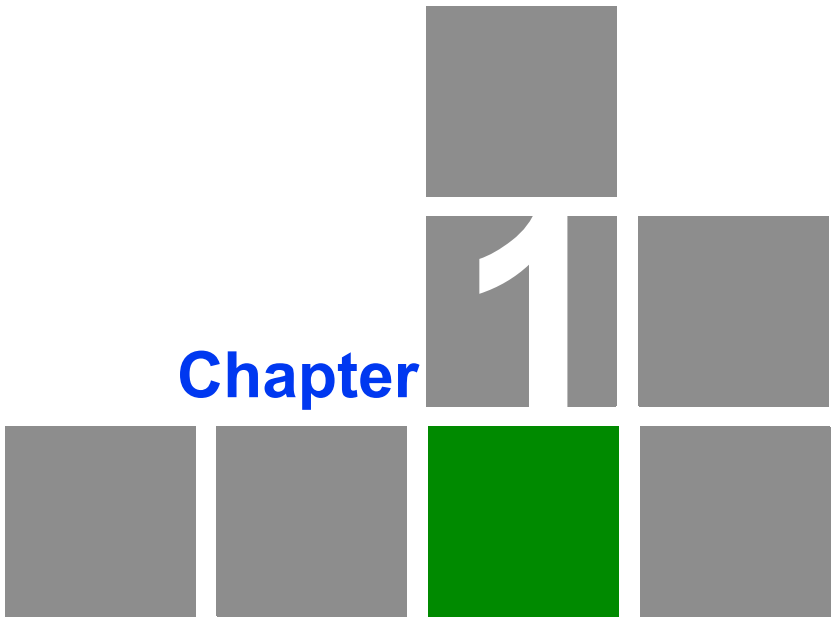




Chapter 1

Introduction

In This Chapter:

- "General Notes" on page 3
- "IP-Address Format" on page 4

1.1 General Notes

This manual lists the commands of the WANFleX operating system.

For device's management and configuration a Unix-like command line interface is used. Every command is having power right after Enter key is pressed. However, each command lifetime duration is limited within one configuration session. In order to save a current configuration "**config save**" command is used.

Several commands can be grouped in one line using ";" character. If a wrong-syntax line is met in the group, the rest of the string is checked anyway and the wrong command is ignored. Command name can be shortened unless the ambiguity occurs.

If your terminal supports VT100 or ANSI standard you can move around the list of recently executed commands using cursor keys. Numbered list of these commands can be reviewed by "**!h**" command. Any command from this list can be available using "**!<NUMBER>**" command. TAB key performs substring search of recently executed commands.

Ctrl/R combination refreshes the command string if its content was disturbed by system messages.

The command executed with no arguments prints a short hint about its keys, parameters and syntax.

Context help can be obtained by printing "**?**" in any position of the line.

1.2 IP-Address Format

Many commands of the operating system require specification of IP-addresses.

In OS WANFleX, the IP-addressees may be specified in traditional numeric format. Optionally, the mask may be specified either by its bit length (the specified number of leading bits in the mask are set to 1, the remaining bits are reset to 0) or numeric value. The IP-address 0/0 denotes all possible IP-addresses.

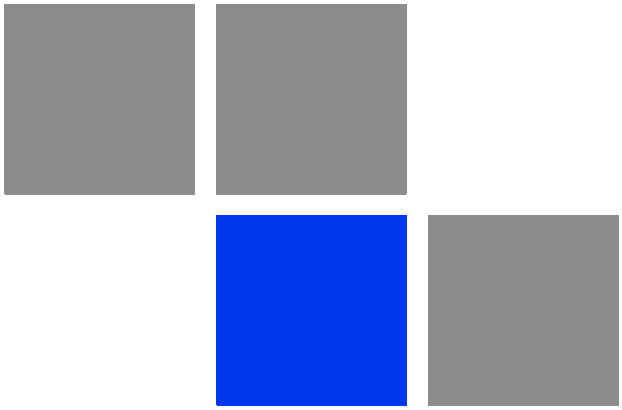
Therefore, the possible formats to specify IP-addresses are:

- nn.nn.nn.nn (no mask is used)
- nn.nn.nn.nn/N (N is the bit length of the mask)
- nn.nn.nn.nn:xxx.xxx.xxx.xxx (xxx.xxx.xxx.xxx is the numerical value of the mask)

Example:

The 192.168.9.0/24 address describes the network address 192.168.9.0 and the mask with leading 24 bits on.

The same set of addresses may be denoted as 192.168.9.0:255.255.255.0.



Chapter 2

General Purpose Command Set

In This Chapter:

- "Help Command" on page 7
- "System Command" on page 8
- "Set Command (Time Zone Settings)" on page 12
- "Config Command (Configuration Manipulations)" on page 13
- "Flashnet Command (Firmware Uploading)" on page 15
- "Restart Command" on page 16
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- "License Command" on page 34
- "Dport Command" on page 35
- "Mem Command" on page 36

2.1 Help Command

The command displays system commands information.

Syntax:

```
help
```

Description:

Displays the list of all device commands. Executed automatically, if the user types an unknown command.

2.2 System Command

The command is used to review and update system parameters.

Syntax:

```
system [arguments]
```

Command arguments:

- **system name [system_name]**

  Assigns to the system a new name specified by system_name parameter. If the parameter is not specified, the current system name will be displayed.

  Example:

  ```
  system name revolution
  ```

- **system location [string_describing_system_location]**

  Optional character string describing the system location; used in SNMP protocol.

  Example:

  ```
  sys location On the Carlsson's rooftop
  ```

- **system user user-name**

  Assigns a name under which the system administrator enters the device from the console or remotely, using telnet/http.

  Example:

  ```
  system user root
  ```

- **system password password**

  Sets the system administrator's password.

  Example:

```
system password qwerty
```

- **system guest key-word-or-phrase**

  Specifies a keyword for entering a guest mode. The keyword is entered as a login, any password may be used. While in the guest mode, you cannot modify the device's configuration parameters, neither security-related parameters.

  Example:

  ```
  system guest for_members_only
  ```

- **system prompt any-word**

  Replaces the prompt on the screen with the given any-word of a maximum length of 16 characters. The resulting prompt will look as "Prompt#ttyN>".

  Example:

  ```
  system prompt MyHost
  ```

- **system uptime**

  Displays the duration of time elapsed since the system's last reset.

- **system OfficialAddress IP-address**

  Sets the IP-address which will be used as a source IP-address in all outgoing connections of the unit.

- **system version**

  Displays the software version.

- **log {on|off} | {show [offset] | clear}| [no]filter | {ADDR | -}**

Manages the system log operation. The optional ADDR parameter specifies the UNIX host where the system log is located to which messages are directed under the standard syslog protocol. The command has the following options:

- **on** - display messages on the current console
- **off** - stop displaying messages on the console
- "**-**" - disable logging on the remote host
- **show** - show the system log listing (the latest message displayed on the bottom line; message time for every message expressed in seconds/milliseconds back from the current time). Offset option shows the log listing in the reversed order.
- **clear** - clear the system log
- **[no]filter** - this option removes neighboring identical lines from system log leaving only one copy of each message and counts their recurrence (enabled by default)

- **factorypassword {single|otp}**

Manages factorypassword modes (Factorypassword - is a password that is requested from Tech-Support when device password is lost). In **single** mode the same factorypassword can be used many times (each time the device password is lost). In **otp** mode factorypasword is expired after each using; so the next time another factorypassword should be requested from Tech-Support.

- **system icmplimit XX**

Sets a limit to the number of outgoing ICMP packets per second (200 by default). Helps to avoid the device rebooting while network scanning programs implementation. When set to 0 all limitations are turned off.

- **system [no]sendredirects**

Enables (disables) the system to send icmp redirect messages for the packets source suppression if routing is incorrectly configured.

- **system [no]dropredirects**

Enables (disables) the system to send icmp redirect messages for routing tables updating if routing is incorrectly configured.

- **system cpu**

  Indicates current CPU load (in percent)

2.3 Set Command (Time Zone Settings)

The command is used for time zone settings manipulations. Automatic summer/winter time switching is supported when timezone is set.

Syntax:

```
set TZ TIMEZONE
```

To delete timezone:

```
set TZ
```

Example:

```
set TZ EST+5EDT,M4.1.0/2,M10.5.0/2
set TZ EKT+5
```

For more details on timezones please visit: **http://www.rt.com/man/tzset.3.html**

2.4 Config Command (Configuration Manipulations)

This command is used to view, save, export, and import the device configuration.

Syntax:

```
config [show | save | clear]
config import | export login:password@host/file
```

Description:

- **show**

  Displays the current configuration of the system. Any change of the system parameters may be immediately viewed using the config show command. The optional parameter may contain a selection of WanFleX commands (abbreviated to their initial letters), as shown in the following examples; only those system parameters will then be displayed which relate to the commands selected.

Example:

```
co show
```

- **save**

  Saves the current system configuration in the device's flash memory for subsequent permanent use. All modifications to the system parameters, if not saved by this command, are valid only during the current session (until the system reset).

- **clear**

  Clears (resets to default) configuration in device flash. To take effect device should be rebooted without saving the configuration.

- **export, import**

  Saves the device configuration on a remote server and reloads it from a remote server. The information is transferred using FTP. The name of the file to or

from which the information is transferred. The file name shall be specified in full, in the format of the remote server's file system.

Example:

```
config export user:secret@192.168.1.1/var/conf/test.cfg
```

2.5 Flashnet Command (Firmware Uploading)

This command uploads a new version of software.

Syntax:

```
flashnet get login[:password]@IP-address/file-name
```

Description:

Loads a new software version into the device from a remote server using FTP. **File-name** is the name of the file containing the information transferred. The file name shall be specified in full, in the format of the remote server's file system. **IP-address** is the IP_address of the remote server.

Example:

```
flashnet get upgrade@192.168.1.1/bnb300v1.2.5.bin
```

Loading consists of two phases:

- Reading the file from the remote server
- Loading the system image in the device memory

The second phase is shown on the screen by repeated sign ".".

2.6 Restart Command

The command performs soft device reset.

Syntax:

```
restart [y]

restart SECONDS

restart stop
```

Description:

Full reset and reinitialization of a device. Equivalent to toggling the power switch off and on. May be used to restore initial configuration after a number of unsuccessful attempts to understand what exactly is done wrong, and after loading a new version of software. With the "y" option, RESTART command is executed immediately, without asking the operator for confirmation.

This command can be used for the postponed reinitialization (after certain number of seconds, e.g. **restart 300**). This option can be useful in case of dangerous manipulations with device's configuration when there is a risk to loose control over the device. The system will periodically inform the user about the time left to reinitialization by putting the corresponding message to the system log. Repeated call of this command will start the countdown from the beginning. **Restart stop** command will cancel a postponed reinitialization.

2.7 Ping Command

The command sends test packets.

Syntax:

```
ping IP [size|-s size_in_bytes] [count|-c count_packets]
   [source|-S IP]
```

Description:

Sends test packets (ICMP_ECHO_REQUEST) to the given IP-address. Enables to estimate attainability of a host and the destination response time. The command has the following parameters:

- **IP-address** - the IP-address of the tested host;
- **size** - the test packet length within the range of 10 to 8000 bytes (optional, 64 by default);
- **count** - the number of the test packets (optional, 5 by default).
- **source** - replaces sender own IP-address with the specified one

Example:

```
ping 192.168.1.1 -s 20 -c 7 -s 192.168.1.9
```

2.8 Telnet Command

Use telnet protocol to enter a remote host.

Syntax:

```
telnet address [port] [-s source]
```

Description:

Sets up a connection with a remote host specified by the **IP-address** in the terminal emulation mode. The **telnet** command uses transparent symbols stream without any intermediate interpretation; therefore, the terminal type is defined by the terminal from which the command has been executed. To interrupt the terminal emulation session, press Ctrl/D.

- **port** - specifies destination port
- **source** - replaces sender own IP-address with the specified one

2.9 Tracrt Command

The command trace attainability of an IP-node.

Syntax:

```
tracert [-s SourceAddress] HostAddress
```

Description:

Traces the packet transmission path up to the IP node (host), specified by the HostAddress parameter.

By default, the sending interface's address is put in the "source address" field of the packets. Using the **-s** option, any other IP address (SourceAddress) may be substituted for this default address.

Tracing is limited to a path with maximum 30 intermediate IP nodes. Trace packets are 36 bytes long. The trace procedure makes 3 attempts for every intermediate node.

Every trace result contains the IP-address of an intermediate node and the response time (in milliseconds) of every attempt.

2.10 Webcfg (Web Interface Support)

Web-interface support module.

Syntax:

```
webcfg start|stop
```

Description:

This command enables/disables Web-interface support on the device. Web-interface allows easy graphical device configuration with the help of a Web-browser.

Example:

```
webcfg start
```

2.11 Rshd Command (Remote Shell)

RSH (remote shell) protocol support module.

Syntax:

```
rshd {enable | ipstat | disable} RUSER RHOST LUSER
rshd start | stop | flush | [-]log
```

Description:

The built-in RSH server makes it possible remote command execution using the rsh program. Identification is based on using privileged TCP ports and a list of authorized hosts.

By default, the RSH server is disabled. To start and stop the server, the commands **rshd start** and **rshd stop** are executed. When started, the server ignores requests for command execution until at least one valid system entry is enabled.

A system entry is specified by an rshd enable command with three parameters:

- **RemoteUSER** - the name of a remote user (up to 16 symbols)
- **RemoteHOST** - IP-address of a remote host
- **LocalUSER** - the name of a local user (up to 16 symbols)

A request for command execution is serviced only if for all three parameters it specifies the values corresponding to a valid entry.

Up to 6 independent entries may be defined.

The name of a local user is in no relation with the WANFleX main authorization system; it may be considered simply as a keyword.

To disable an entry, an **rshd disable** command is executed with parameters defining that entry.

The **rshd flush** command clears the rsh server configuration.

The RSH server may be conveniently used e.g. for periodic reading of a device statistics using **ipstat** option:

```
rsh ipstat admin bnb.domain.com mysecretuser
```

Log option enables "rshd" service messages to be written into system log.

Example:

```
rshd enable admin 195.38.44.1 mysecretuser
rshd enable root 195.38.45.123 mysecret2
rshd start
```

2.12 Ipstat Command (IP-Statistics)

IP statistics gathering module.

Syntax:

```
ipstat enable [incoming|outgoing|full] [detail] [SLOTS] |
   disable

ipstat clear

ipstat traf [detail] [bytes | total_bytes]

ipstat fixit | fixget| fixclear

ipstat strict | -strict

ipstat add [intf] rules...

ipstat del num
```

Description:

The IP statistics gathering module provides for collecting information on dataflows traversing the device, for further analysis and/or for accounting.

Information is accumulated in the device's RAM memory as a series of records having three fields: source address, destination address, number of bytes transferred. By default, only outgoing packets are counted, at the moment they are sent to a physical interface. One record takes 12 bytes.

The maximum number of records is specified by the items numeric parameter of an ipstat enable items command; it shall not exceed the size of memory available. By default the number of records is 1000; typically it's sufficient for recording 15 to 20 minutes of operation of a client unit.

Accumulated information is displayed on the current terminal (or rsh session) using the following commands:

- **ipstat enable [incoming|outgoing|full] [detail] [SLOTS] | disable** - enables/disables ip statistics gathering. It can allow gathering only **incoming/outgoing** or **full** (both) dataflows. **Detail** option switch on detailed ip statistics gathering including ports and protocols information. **SLOTS** option allows setting the maximum number of rows in the ipstat table.

- **ipstat clear** - clear accumulated statistical info

- **ipstat strict**

A more reliable method of remotely getting statistical info consists in using the following commands:

- **ipstat fixit** - dumps the currently collected info from the device's memory into an intermediate buffer. The memory is cleared, and continues receiving info over again.
- **ipstat fixget** - shows the content of the dump buffer. This command may be executed any number of times, with no damage to the dumped statistical info.
- **ipstat fixclear** - clears the temporary dump buffer

The listing of statistical info provides:

- time elapsed since the previous "clear" operation
- number of records effectively used, and total record space available
- number of bytes lost due to record memory overflow list of all records.

If the record table in the device memory overflows, or if there is not enough memory currently available, an appropriate warning is written into the system log, and further statistical data are discarded. If **strict** option is enabled then at the overflow condition the transit routing is disabled but the device still responds to any protocol.

The **ipstat add [ifname] rule** command makes it possible to filter packets for statistic gathering, taking into account only those packets which satisfy the rule. The syntax of the "**rule**" parameter is the same as defined in the **ipfw** command description.

The **ipstat del N** command deletes the N-th rule from the list of rules.

The **ipstat traf [detail] [bytes | total_bytes]** allows for visually inspecting statistics collection process in real time. **Detail** option switch on detailed ip statistics gathering including ports and protocols information.
Bytes(/total_bytes) option sort ipstat output according to the number of transmitted bytes in the moment(/bytes transmitted for the whole period).

This is the script for the reliable device statistics receiving with **rsh** command usage:

```
#!/usr/bin/perl -w
for(;;)
{
   my $stat;
   do
   {
      $stat = system("rsh -t 30 -n -l root IP
 ips fixit >/dev/null");
      if(int($stat) != 0) { sleep(5); }
   } while (int($stat) != 0);
   do
   {
      $stat = system("rsh -t 30 -n -l root IP
 ips fixget >stat.tmp");
      if(int($stat) != 0) { sleep(5); }
   } while (int($stat) != 0);
   do
   {
      $stat = system("rsh -t 30 -n -l root IP
 ips fixclear >/dev/null");
      if(int($stat) != 0) { sleep(5); }
   } while (int($stat) != 0);

   system("cat stat.tmp >>stat.txt");

   sleep(300);
}
```

2.13 Sflowagent (Sflow Agent)

Sflow Agent is a realization of a standard STP protocol agent.

Syntax:

Available commands are:

```
sta[rt] Start Sflow agent

sto[p] Stop Sflow agent

add[instance] 'name' Add instance (default 'ipstat')

del[instance] 'name' Delete instance (default 'ipstat')

stat 'name' Show statistics for instance (default 'ipstat')

cl[earstat] 'name' Clear statistics for instance (default
   'ipstat')
```

Available options are:

```
-collector=IPaddress[:port] Set collector address

-agent=IPaddress Set agent address (default 0.0.0.0)

-maxpacket=size Set maximal datagram size (default 1500)

-interval=number Set statistics recieve interval, in seconds
   (default 5)

-datagrams=number Set datagrams per statistics interval
   (default 100)

-rawheader={on|off} Sends original ipV4 headers (default off)

-debug={on|off} Puts debug output to log (default off)

-version -v Display Version
```

Description:

Sflow - protocol for monitoring computer networks. It is commonly used by Internet Providers to capture traffic data in switched or routed networks. *Sflowagent* command allows configuration of Sflow agent on the device.

- **sflow sta[rt]** - starts Sflow agent
- **sflow sto[p]** - stops Sflow agent

- **sflow add[instance] 'name'** - adds statistics gathering component (if 'name' parameter is not specified then 'ipstat' component will be used)

- **sflow del[instance] 'name'** - deletes statistics gathering component (if 'name' parameter is not specified then 'ipstat' component will be used)

- **sflow stat 'name'** - shows statistics for a component (if 'name' parameter is not specified then 'ipstat' component will be used)

Command output:

Parameter	Description
Total flow records	Number or records delivered from *Instance*.
Total flow samples	Number of grouped records delivered from *flow records*.
Overflow records	Number of records in *Instance* for all cases when *Instance* overflowed earlier then *interval* period had ended.
Overflow count	Number of times when *Instance* overflowed earlier then *interval* period had ended.
Total cycles	Overall number of gathering statistics success cycles.
Total datagrams	Overall number of sent datagrams.
Unused datagrams	Number of datagrams that could be created in compliance with *datagrams* parameter but was not used.
Bytes sent	Overall number of transmitted data by Sflow protocol.
Lost flow samples	Number of *flow samples* that were discarded because of *maxpacket*, *interval* and *datagrams* parameters low values.
Lost flow records	Number of *flow records* that were discarded because of *maxpacket*, *interval* and *datagrams* parameters low values.
Lost overflow records	Number of times when *Instance* overflowed earlier than the *interval* period ended and data were lost.

- **sflow cl[earstat] 'name'** - clears statistics for a component (if 'name' parameter is not specified then 'ipstat' component will be used)

- **sflow collector=IPaddress[:port]** - sets address of a collector that process sflow-packets. Default port is 6343.

- **flow -agent=IPaddress** - sets agent's own address (device)

- **sflow -maxpacket=size** - sets maximum size of a Sflow-packet in bytes. 1500 bytes by default. Upper bound is limited by hardware and operational system capabilities. In case of its exceeding packet size will be decreased to acceptable value.

- **sflow -interval=number** - time in seconds equal to interval with which statistics is delivered from instance. Increasing of this parameter leads to increasing in overall system efficiency but in case of unexpected network activity splash data could be lost. 5 seconds by default.

- **sflow -datagrams=number** - maximum number of datagrams between times of receiving statistics from instance. The increase of this parameter leads to the decrease in datagram average size and increases in theoretical number of delivered statistics data. Reduces the load on the CPU but in the same time reduces overall system efficiency. However, reducing of system efficiency doesn't happen with low traffic. It is recommended to increase this parameter when decreasing maxpacket parameter and/or when increasing interval parameter. 100 by default. Maximum flow: sflow= datagrams/interval* maxpacket, (Bytes/sec).

- **sflow -rawheader={on|off}** - sends original ipV4 headers in spite of statistics data (off by default). Used for compliance with traffic monitoring programs.

- **Sflow -debug={on|off}** - puts statistics information to log.

Example:

```
ipstat enable full detail 3000 # starting the process of
   gathering statistics

sflow add ipstat # adding gathering component

sflowagent -agent=LOCAL_IP_ADDRESS
   -collector=SERVER_IP_ADDRESS

sflowagent start # starting process of processing the
   statistics
```

2.14 Acl Command (Access Control Lists)

Access Control Lists.

Syntax:

```
acl add $NAME TYPE params...

acl del $NAME [params...]

acl ren $NAME1 $NAME2

acl flush
```

Possible TYPES:

```
net num
```

Predefined ACL names:

```
$ACLOCAL - Hosts (networks) permitted to configure the
   device.
```

Command description

While network planning you may often need to group similar parameters in lists which can be used for different filters (e.g. **ipfw**, **qm**, **ipstat**). Access control lists (ACL) can effectively solve this problem.

acl add command creates an access list of NAME title and TYPE type. Lists names MUST start with $ symbol and can include up to 7 letters, digits and other symbols excluding spaces and semicolon. At the same time the command can contain several parameters of TYPE type which will be included in the list. If the list with this name has been already created listed parameters will be attached to this list.

acl del command deletes specified parameters from the NAME list. If none of parameters are mentioned all list will be deleted.

acl rename command changes list's name from NAME1 to NAME2.

acl flush command deletes all lists

Accepted list types (TYPE):

net - contains network addresses in dot format.

xxx.xxx.xxx.xxx or **xxx.xxx.xxx.xxx/MASK_LENGTH** or

xxx.xxx.xxx.xxx/xxx.xxx.xxx.xxx

Lists of net type optimize their parameters by excluding duplicates and by having the feature that enables bigger networks include smaller networks. For example, if the list contained 1.1.1.1 parameter, when you include 1.1.1.0/24 parameter in the list 1.1.1.1 will be excluded.

Example:

```
acl add $LIST1 net 10.0.0.0/8 192.168.0.0/16 5.5.5.5
acl del $LIST1 5.5.5.5
```

Reserved access lists:

$ACLOCAL - reserved list for access limitation to the device via telnet, ftp and http protocols. Having "$ACLOCAL" access list in the configuration all attempts to establish a connection with the device from addresses (networks) that are not in this list will be rejected.

Example:

```
acl add $ACLOCAL net 10.0.0.0/8 192.168.0.0/16
```

2.15 Sntp Command

SNTP parameters management.

SNTP support developed in WANFleX lets the system to synchronize the time with configured NTP server using fourth version of SNTP protocol **RFC 2030**.

Client works in unicast server request mode in certain time range.

Syntax:

```
sntp [options] [command]
```

Commands are the following:

- **start** - start service
- **stop** - stop service

Options are the following:

- -server={ipaddr} - set sntp server address
- -interval={seconds} - specify poll interval in seconds
- -debug={on|off} - enable/disable debug information

Example:

```
sntp -interval=3600 -debug=on
sntp -server=9.1.1.1 start
```

Commands:

- **start**

  Make the process of time synchronization active.

Example:

```
sntp start
```

- **stop**

  Stop the process of time synchronization.

Example:

```
sntp stop
```

Parameters:

The parameters can be set using any sequence with or without the command itself.

- **server**

  Using the **server** parameter, you can set the IP-address of your NTP server.

Example:

```
sntp -server=9.1.1.1
```

- **interval**

  Using the **interval** parameter, one can set the time value (in seconds) defining client's periodicity of NTP server requesting. 3600 by default.

Example:

```
console> sntp -interval=5000
```

- **debug**

  This parameter enables/disables printing of debugging information (packets) in the system log of WANFleX OS.

Example:

```
sntp -debug=on
sntp -debug=off
```

2.16 Date Command

Date and time management.

This command shows or sets the date and time in WANFleX system.

Syntax:

```
date [[[[[cc]yy]mm]dd]HH]MM[.ss]]
```

cc - Century (is added before Year)

yy - Year in abbreviated form (i.e. 89 for 1989, 05 for 2005)

mm - Month in numeric form (1 to 12)

dd - Day (1 to 31)

HH - Hour (0 to 23)

MM - Minute (0 to 59)

ss - Second (0 to 61 - 59 plus maximum two leap seconds)

Example:

```
date 200402100530.04
Tue Feb 10 05:30:04 2004


date
Tue Feb 10 05:30:10 2004
```

2.17 License Command

This command manages operations with a license file on the device.

Syntax:

```
license [options]
```

Options are:

```
--install=<url> - install new license
--export=<url>  - export current license to external server
--show          - show license info
<url> = ftp://[login[:password]@]host/file
```

Description:

Install option uploads license file into the device from a remote server using FTP.

Export option downloads license file from the device to a remote server using FTP.

Show option displays license information on the screen.

File-name is the name of the file containing the information transferred. The file name shall be specified in full, in the format of the remote server's file system.
IP-address is the IP_address of the remote server.

Examples:

```
li
   --export=ftp://ftp_login:ftp_password@192.168.145.1/licens
   e_file
li -show
```

2.18 Dport Command

Syntax:

```
dport BAUD
```

Description:

This command sets a bitrate of the console port. Available values are: 9600, 19200, 38400, 57600, 115200 Bit/sec. Default value is 38400 Bit/sec.

2.19 Mem Command

Syntax:

```
mem
```

Description:

This command show statistics for allocated device memory, network buffers, queues and drops on interfaces. Command output is described in the picture below.

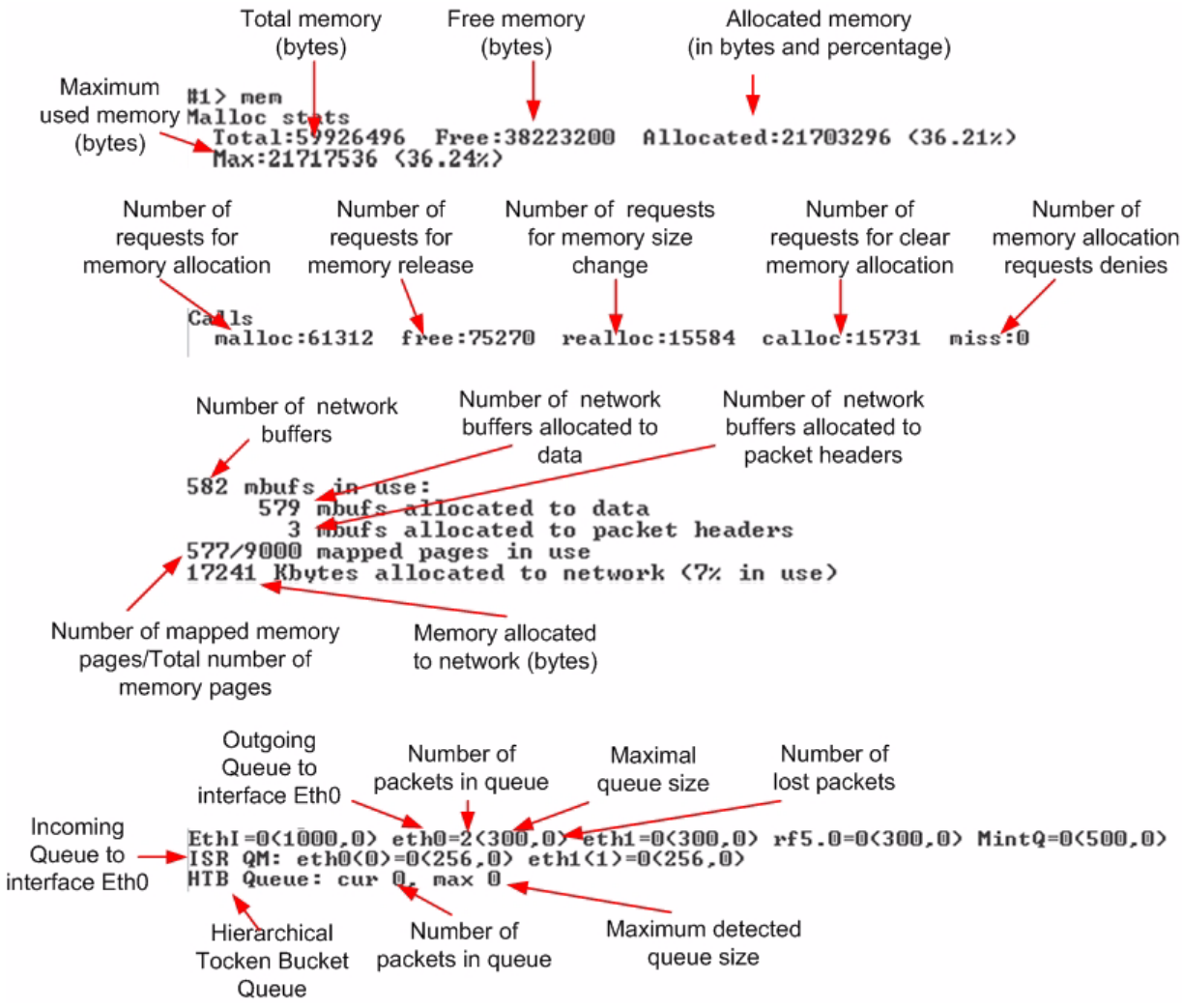
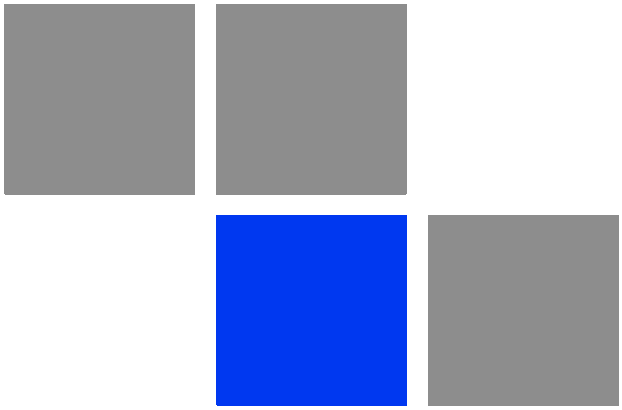


Figure 2-1: Mem Command



Chapter 3

Layer 2 Command Set - PHY and MAC

In This Chapter:

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- "Mint Command" on page 43
- "Ltest (Radio Link Test)" on page 62
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- "Switch Command" on page 81
- "Dfs (Dynamic Frequency Selection)" on page 99

3.1 Rfconfig Command (Radio Interface Configuration)

The command is used to configure a radio module.

Syntax:

```
rfconfig IFNAME Options
```

where Options:

```
band  XXX:  bandwidth (MHz) - {double (40)|full (20)|half
   (10)|quarter (5)}

freq  XXX:  central frequency

bitr  XXX:  bitrate (Kbps)

sid   XXX:  system identifier - 8 hex digits.

pwr X: output power

dist  XXX:  distance in kilometers or auto

[noise XXX]
```

where Commands:

```
rfconfig IFNAME capabilities

rfconfig IFNAME statistics
```

Options description:

Sets parameters of a radio module specified by the **IFNAME** (name of the radiointerface) parameter, or displays them if executed without any optional parameter. Optional parameters are as follows:

- **band XXX**: this option allows choosing the channel width for transmitting. **Double** means 40 MHz, **Full** - 20 MHz, **half** - 10 MHz, **quarter** - 5 MHz. Units in one PTP connection must have the same channel width. Example:

  rf rf5.0 band half

- **bitr XXX**: the bit transfer rate (in Kbit/s) of the radio link. Allowed values depend on selected channel width:
  - **5 MHz**: 3250, 6500, 9750, 13000, 19500, 26000, 29250, 32500 Kbit/s
  - **10 MHz**: 6500, 13000, 19500, 26000, 39000, 52000, 58500, 65000 Kbit/s
  - **20 MHz**: 13000, 26000, 39000, 52000, 78000, 104000, 117000, 130000 Kbit/s
  - **40 MHz**: 30000, 60000, 90000, 120000, 180000, 240000, 270000, 300000 Kbit/s
- **Freq XXX**: the radio link frequency (in MHz).

  The list of allowed frequencies can be obtained by executing "**rf if-name cap**" command.
- **Sid XXX**: system identifier of the device, a hexadecimal number in the range of 1H to FFFFFFH. All devices that are supposed to see each other on the same radio link must have the same identifier.
- **pwr**: sets the emitting power of a transmitter (in milliwatts).

  The values of acceptable transmit power levels can vary depending on the type of radio module. The full list of acceptable transmit power levels is available by using "**rf if-name cap**abilities" command. If the value entered is invalid the system will keep the previous valid setting.

  "**[-]pwrctl**" option enables ATPC (automatic transmit power control) function on the device interface. When it is enabled (**rf rf5.0 pwr <power> pwrctl**) the system will maintain the lowest possible (optimal) power level necessary to achieve maximum productivity.
- **distance XXX**: this parameter is used as an alternative method of link range configuring in order to set the exact distance value between two devices (in kilometers). This parameter changes time values for some delays and time-outs thus making possible to work on longer distances with smooth adjustment.

There are several ways to manage this parameter:

- If you set an exact value, this value is used no matter what the connection method is used
- If you use the **auto** value instead of a number (by default), the unit will configure its parameters automatically. While the configuration is displayed, there might be the current distance value after the **auto** parameter: **auto (XX). Auto mode is recommended**

If **distance** parameter is set to 0, radio module will work for 0-3 km distances.

- **noise** sets Noise Floor Threshold for radio interface. Measured in decibel. By default Noise Floor Threshold is 25 db. Noise Floor Threshold is defined as a positive shift relative to the current level of noise which is measured by a device. The unit begins data transmission only when there are no signals in the air that have signal level higher than Noise Floor Threshold. See Noise Floor and Noise floor Threshold values with "rf IFNAME stat" command.

Commands Description:

- **statistics**: displays current values of the radio module's statistics with 1 sec interval.

The table below shows the "**rfconfig stat**" command output:

Table 3-1: "rf stat" output for 5GHz devices

Parameter	Description
Broadcast rate	Current bitrate value for Broadcast and Multicast packets
Voice Mode	ON/OFF value. If turned ON, the mode of their prioritized processing is turned on
Bytes Received	Number of received bytes including headers
Bytes Transmitted	Number of transmitted bytes including headers
Packets Received OK	Number of correctly received packets
Packets Transmitted OK	Number of correctly transmitted packets
Duplicate Received	Number of duplicate packets received due to protocol excesses
Aggr duplicates	Number of duplicate aggregates received
Aggr drops	Number of packet drops in an aggregate due to protocol excesses (in receiving)

Table 3-1: “rf stat” output for 5GHz devices

Parameter	Description
Total Retries	Total number of retries
FIFO Overrun	Number of FIFO queues overruns in the radio when receiving
FIFO Underrun	Number of FIFO queues underruns in the radio while transmitting
CRC Errors	Number of received packets with CRC errors
Excessive Retries	Number of packets which were not transmitted with maximal number of retries
Noise Floor	Input noise level. Measurement cycle -10 seconds
Noise Floor Threshold	Noise Floor Threshold for Carrier Detect
Decrypted frames	Number of successfully decrypted packets
Decrypted errors	Number of errors in the decryption process
Replay drops	Number of packet drops in an aggregate due to the packet sequence errors
Aggr Subframe Retries	Number of packet drops in an aggregate due to protocol excesses (for transmission)
Aggr Full Retries	Number of duplicate aggregates transmitted
Max aggr frames	Maximal detected number of packets in an aggregate
Max aggr bytes	Maximal detected bytes in an aggregate
Encrypted frames	Number of successfully encrypted packets

- **capabilities**: displays the radio module's internal information on its operating features including acceptable transmit power levels, frequencies etc.

Examples:

```
rfconfig rf5.0 sid 1 bitr 130000 freq 5725

rfconfig rf5.0 bitr 39000 freq 5280 sid 01020304

rfconfig rf5.0  pwr 63 distance auto
```

3.2 Mint Command

3.2.1 General Description

MINT - **Microwave Interconnection NeTworks** - architecture gives a functionality to present a radio interface of a unit (as well as a network connected to it) as a traditional Ethernet in a bus topology. Therefore the unit can have several Ethernet interfaces and several pseudo-interfaces (tun, ppp, null etc). Any of Ethernet interfaces can be united in bridging groups which consist of two or more interfaces. Moreover, routing mode can also be used.

Full syntax:

```
mint IFNAME -type {master | slave}

mint IFNAME -mode {mobile | nomadic | fixed}

mint IFNAME -nodeid NUMBERID

mint IFNAME -name NAME

mint IFNAME -key SECRETKEY

mint IFNAME -authmode {public | static | remote}

mint IFNAME -[no]authrelay

mint IFNAME  -[no]snmprelay

mint IFNAME -[no]autobitrate [+/-DB] | -fixedbitrate

mint IFNAME  -autofactor 1..5 [3]

mint IFNAME -ratefall X

mint IFNAME -minbitrate XX

mint IFNAME [-loamp XX] [-hiamp XX]

mint IFNAME -[no]crypt [aes]

mint IFNAME -airupdate {disable | {active [force] | passive}}
   [fast|normal|slow]

mint IFNAME -[no]log [detail]

mint IFNAME profile N [-freq XX[,YY,..] | auto] [-sid
   XX[,YY,..]] [-bitr XX]

            [-band {double | full | half | quarter}]

            [-type {master|slave}] [-key XXX] [-nodeid N]

            [{-minbitr XXX [-autobitr [+/-dB]] | -fixedbitr}]
```

```
                [enable | disable | delete]
mint IFNAME roaming {leader | enable | disable}
mint IFNAME addnode -mac X:X:X:X:X:X [-key STRING] [-note
   STRING]
                [-maxrate XX]
                      [-lip X.X.X.X] [-tip X.X.X.X] [-mask
   X.X.X.X]
                      [-lgw X.X.X.X] [-tgw {X.X.X.X | none}]
                      [-lcost XX] [-tcost XX] [{-setpri |
   -addpri} NN | -1]
                      [-disable | -enable | -delete]
mint IFNAME delnode -mac X:X:X:X:X:X
mint IFNAME map [neighbors | routes | full | swg] [detail]
   [-n] [-m]
mint IFNAME monitor [-s] [-i SEC] [MAC [MAC ...]] [full]
mint IFNAME rcmd -node {ADDR|all} [-local] {-cmd "CMD" |
   -file URL} [-key KEY] [-quiet]
mint IFNAME -rcmdserver {disable | enable} -guestKey STRING
   -fullKey STRING
mint -[no]colormap
mint IFNAME start | stop | restart | clear
mint IFNAME poll {start [log] | stop | stat [clear]}
mint vers
```

3.2.2 General Commands Description

3.2.2.1 Setting the node type

Syntax:

```
mint IFNAME -type {master | slave}
```

The command sets the type of node.

Three node types are available:

- **MASTER:**

Master can establish connections with all other types of nodes. He is able to form a network of any topology with other masters or slave type.

On master node a marker access (**polling**) can be enabled.

- **SLAVE:**

Can only connect to the node with master type. With loss of the connection attempts to restore the connection to the master node.

Example:

```
mint rf5.0 -type master
```

3.2.2.2 Setting the node mode

Syntax:

```
mint IFNAME -mode {mobile | nomadic | fixed}
```

The command sets the mode of the node. The mode is defined by the application of the node for the network. Modes description:

- **Fixed**. The network node has a fixed allocation and never moves and never is switched off. This is a infrastructure node of the network
- **Nomadic**. Node may change its physical allocation but all the data transmitting is made when the node is not moving (or moving very slowly)
- **Mobile**. The node may move and exchange data while moving

Example:

```
mint rf5.0 -mode nomadic
```

3.2.2.3 Setting node sequential number

Syntax:

```
mint IFNAME -nodeid NUMBERID
```

The command sets the sequential number for the node. The parameter is optional.

Example:

```
mint rf5.0 -nodeid 5
```

3.2.2.4 Setting node name

Syntax:

```
mint IFNAME -name NAME
```

The command sets the name for the node. Node name will be displayed in "**mint map**" set of commands. Node name should not exceed 16 characters and should not contain spaces.

Example:

```
mint rf5.0 -name My_node
```

3.2.2.5 Switching to marker access mode (polling)

Syntax:

```
mint IFNAME poll {start [log] | stop | stat [clear]}
```

The command turns on/off polling mode for the master station.

Polling mode is a method of accessing common radio channel under master station control, which consists in centralized distribution of transmission authorization markers by a master station to slaves. It is particularly useful when slaves units are at long range from a master station and not in the direct visibility of each other, so that they cannot avoid mutual collisions in the radio channel by listening each other's transmission.

Despite a slight decrease in the maximum transmission speed, the polling mode substantially increases the total throughput of a master. The polling algorithm is so designed as to minimize the protocol overhead while maintaining high efficiency and robustness.

The polling mode is enabled on the master station only. Configuration of client units needs not to be modified.

For fine tuning of polling regime there are three optional parameters which can be set using the following syntax:

```
mint IFname poll start [mi=XX] [ub=XX] [mt=XX]
```

- **MI** - Marker Interval. The primary time unit used in calculating the marker sending frequency. The approximate value is a half of the round-trip delay for the interface. Values are given in milliseconds, from 4 to 20.

- **UB** - Upper bound. Marker sending interval upper bound. This value provides a minimal guaranteed marker sending frequency. This parameter is chosen based on the compromise between the total number of markers loading up the

channel for no purpose and the response time for the first key pressed in telnet program. The value is within 50 and 1000 ms. 800ms by default.

- **MT** - Marker Timeout. The maximum waiting time for a client unit response to a marker or data packet. Expressed in milliseconds; default value is 120 ms.

Example:

```
mint rf5.0 poll start ub=250
```

3.2.2.6 Switching to automatic bitrate control mode

Syntax:

```
mint IFNAME -[no]autobitrate
```

Enables/disables an automatic speed management mode.

In autobitrate mode every device controls the connection parameters independently (amplitude of the received signal, number of ARQs on transmitting, errors, SNR on the opposite side etc) and chooses such transmitting speed which provides necessary conditions for a reliable work with minimum number of ARQs and losses. Speed values can be different for each direction but it will be optimal.

When no autobitrate is used transmitting speed will be set according to the setting of "bitr" parameter of "rfconfig" command. When autobitrate is used, transmitting speed will be automatically adjusted according to current link conditions. The ranges of speed will be in between the setting of "bitr" parameter in "rfconfig" command (maximal speed) and "minbitrate" parameter (see below). If no "minbitrate" is specified the minimal RF interface speed will be taken as a lowest possible transmitting speed.

Minimal transmitting speed for autobitrate mode can be set with a help of the following command:

```
mint IFNAME -minbitrate BITRATE
```

Example:

```
mint rf5.0 -autobitrate
```

```
mint rf5.0 -minbitrate 9000
```

Mint <IFNAME> -ratefall X command allows influencing autobitrate mechanism. It sets upper bitrate index threshold below which errors and retries checks are not performed, just energetic ability to upper bitrate is taken into consideration. Bitrate indexes are from 1 to 8 and correspond with bitrates available on the device's radio interface (to see bitrate list use "rf rfX cap" command). "0" ratefall's value cancels the command.

Example:

```
mint rf5.0 -ratefall 4
```

3.2.2.7 Setting signal levels thresholds

Syntax:

```
mint IFNAME [-loamp XX] [-hiamp XX]
```

- **loamp**. This option sets the minimal signal level for the neighbor. Signal level is measured in dB above the noise threshold for the current bitrate. If the level gets lower than specified value the connection with a neighbor will be lost. Default value - 8

- **hiamp**. This option sets the minimal SNR for a new neighbor. Signal level is measured in dB above the noise threshold for the current bitrate. If neighbor's signal level is equal or higher than a specified value the node will consider this neighbor to be a candidate. Default value - 14

Example:

```
mint rf5.0 -loamp 2
```

3.2.2.8 Creating local nodes database

Syntax:

```
mint IFNAME addnode -mac X:X:X:X:X:X [-key STRING] [-note
   STRING]
                [-maxrate XX]
                      [-lip X.X.X.X] [-tip X.X.X.X] [-mask
   X.X.X.X]
                      [-lgw X.X.X.X] [-tgw {X.X.X.X | none}]
                      [-lcost XX] [-tcost XX] [{-setpri |
   -addpri} NN | -1]
                      [-disable | -enable | -delete]
```

This set of parameters defines the nodes with which a node can work with. The following parameters can be specified:

- **mac**. This parameter is mandatory. X:X:X:X:X:X is a MAC-address of the node with which a connection can be established.

- **key**. Unique unit's key (key word or phrase up to 64 characters long; if contains spaces should be put into quotes). Used in authentication procedures. The same key should be specified in the settings of the connecting unit ("mint IFNAME -key").

- **lip**. Local IP-address. This address will be assigned to this unit when the connection with a remote is established

- **tip** and **mask**. Target IP-address and mask. This address will be assigned to the remote side when a connection is established. The mask is applied to both Local IP and Target IP. If mask is not specified these addresses will not be used

- **lgw**. Local gateway IP-address (will be assigned to the local node once connection is established)

- **tgw**. Target gateway IP-address (will be assigned to the remote node once connection is established). **None** option disables target gateway IP-address assigning.

- **lcost**. Local cost of the connection to this neighbor from current node. If not specified, MINT will automatically calculate the cost

- **tcost**. Target cost of the connection from this neighbor to the current node. If not specified, MINT will automatically calculate the cost. If **lcost** and **tcost** parameters are set on a pair of neighbors, **lcost** has a higher priority.

- **enable/disable/delete**. Self-explanatory - enables, disables or deletes a record in a local database.

- **maxrate**. Target node maximum bitrate in kilobit per second.

- **setpri | addpri**. This options allows setting/increasing the priority of packets passing through to the specified node. "**Setpr**i" parameter is used to change a priority to the value specified in the command. When using "-1" value a package priority is dropped to the lowest priority. "**Addpri**" is used to change a priority only in case it is higher than the previous one (Note: the smaller is the value the higher is the priority). So you can only increase priority using "**addpri**" parameter.

- **note**. This option allows making some word note (description) for the specified node.

Example:

```
mint rf5.0 addnode -mac 000028BAF234 -lip 1.1.1.1 -tip
   1.1.1.2 -mask 255.255.255.252 -lcost 120
```

3.2.2.9 Deleting a node from local database

Syntax:

```
mint IFNAME delnode -mac X:X:X:X:X:X
```

The command deletes a record created using "addnode" command with a corresponding MAC-address.

Example:

```
mint rf5.0 delnode -mac 000028BAF234
```

3.2.2.10 Managing MINT protocol

Syntax:

```
mint rf5.0 start | stop | restart | clear
```

The command starts, stops, restarts MINT protocol or clears (deletes) MINT configuration.

Example:

```
mint rf5.0 start
```

3.2.2.11 MINT log settings

The following command is used to control log settings for MINT protocol:

```
mint IFNAME -[no]log [detail]
```

Three different modes are available:

- No logging. "-**nolog**" option is used
- Limited logging. "-**log**" option is used. The messages on connecting/disconnecting neighbors will be put to the system log
- Detailed logging. "-**log detail**" option is used. Along with the messages from limited logging mode, messages on changing costs of the routes and changing bitrates (in autobitrate) mode will be put to the system log

Example:

```
mint rf5.0 -log detail
```

This command will turn full logging on.

3.2.2.12 MINT protocol version

Syntax:

```
mint vers
```

The command shows current version of MINT protocol.

3.2.3 Nodes Authentication

Setting the secret key:

```
mint IFNAME -key SECRETKEY
```

This command sets the secret key for the current node. See different authentication modes descriptions below to learn how it is being used. The key can be up to 64 characters long and should not contain spaces (or should be put in quotes).

```
mint IFNAME -authmode {public | static | remote}
```

The command sets the type of nodes authentication.

There are three types of nodes authentication available:

- **public** - all nodes have the same key (password) for access. The simplest case of authentication. It can be used for small workgroups, point-to-point connections, mass public access networks and for MINT architecture testing purposes. Any two nodes of the network can establish a connection (given other settings are suitable) if their keys are equal. In public mode, having found a potential neighbor a node check for its information in the local database (defined by "mint IFNAME addnode" commands). If requested information is found, a key from a local database will be used. Otherwise, it is assumed that neighbor's key corresponds with node's own key ("mint IFNAME -key" parameter)

- **static** - every node has a full list of nodes (including their parameters and access keys) with which a connection can be established. This mode is suitable for an autonomous area of service with no need of centralized management and monitoring. Obviously, nodes that are included in each others access lists (local databases) should have a physical ability to connect to each other in order to establish a connection. In static mode each node must have a list of all permitted neighbors in a local database formed by a set of "mint IFNAME addnode" commands. If no information on the neighbor is found in the database the connection is being rejected.

- **remote** - centralized authentication mode with remote. In this mode any node can request the information from a remote authentication server. This means that the node must have an access to this server (e.g. using IP).

A node having a local database of its neighbors or having an access to a remote authentication server can be configured as an **authentication relay**. For this purpose the following command is used:

```
mint IFNAME  -[no]authrelay
```

The information about authentication relay will be automatically distributed throughout the MINT network. Nodes which use remote mode of authentication but both do not have access to the remote server and do not have the information in their local database will use authentication relay in order to obtain the keys of potential neighbors.

Example 1:

Nodes A and B use the same key and can establish a connection with each other in public authentication mode.

Node A:

```
mint rf5.0 -key SECRETKEY
mint rf5.0 -authmode public
```

Node B:

```
mint rf5.0 -key SECRETKEY
mint rf5.0 -authmode public
```

Example 2:

Nodes A and B have different keys but they can establish a connection with each other using their local databases.

Node A:

```
mint rf5.0 -key SECRETKEY
mint rf5.0 -authmode public
mint rf5.0 addnode -mac B:B:B:B:B:B -key KEY2
```

Node B:

```
mint rf5.0 -key KEY2
mint rf5.0 -authmode public
mint rf5.0 addnode -mac A:A:A:A:A:A -key SECRETKEY
```

Moreover, each of these two nodes can set up connections with other nodes working in public mode if their keys correspond with each other.

Example 3:

Node A has a local database and acts as an authentication relay. Node B does not have a database and uses a relay in remote mode

Node A:

```
mint rf5.0 -key KEY1
mint rf5.0 -authmode static
mint rf5.0 -authrelay
mint rf5.0 addnode -mac B:B:B:B:B:B -key KEY2
mint rf5.0 addnode -mac A:A:A:A:A:A -key KEY3
```

Node B:

```
mint rf5.0 -key KEY2
mint rf5.0 -authmode remote
```

Node B will be getting neighbors' information via relay (Node A).

If Node A is switched to remote mode and there is no information in the local database, the authentication request will be forwarded to the remote server (if specified and accessible) or to another authentication relay.

```
mint IFNAME  -[no]snmprelay
```

The information about SNMP relay will be automatically distributed throughout the MINT network. Nodes will use remote SNMP services.

```
mint IFNAME  -autofactor 1..5
```

This command sets a "sensitivity" for the device to establish a connection with a candidate via a radio interface. The more the autofactor value the better should be radio parameters of the link for the device to establish a connection. Default value is 3.

3.2.4 Automatic Over-the-Air Firmware Upgrade

```
mint IFNAME -airupdate {disable | {active [force] | passive}}
   [fast|normal|slow]
```

This set of commands manages Automatic Over-the-air firmware update system.

3.2.4.1 What is it?

AirUpdate system provides with an easier ways of massive firmware upgrade in the MINT network for a big number of the nodes (same type). In order to do that only one unit of each type should be manually (or through the scheduler) upgraded - other units will get new firmware automatically.

3.2.4.2 How does it work?

Every unit can be configured for AirUpdate in passive or active mode. Active units periodically (every 30 minutes) announce the information about their firmware to the MINT network. The information includes the version of the firmware and the time of uninterrupted (without reboots) work with this version. All units of MINT network (both active and passive) receive and accumulate the information from active units choosing the source with the latest version of firmware with which the source has worked for the longest period of time.

After the period of information accumulation passive units send their requests for the new firmware to the chosen source. Active units form a list of requests and perform a group distribution of the firmware using special MINT multi-address distribution protocol.

The period of information accumulation can be changed using **fast**, **normal** and **slow** parameter of the command.

In **fast** mode the unit will wait for the potential source of the firmware to work with new version within two hours with no reboots. Only after two hours the request will be sent.

In **normal** mode the waiting period is 7 hours; in **slow** - 24 hours

By default, **passive normal** mode is turned on.

For immediate firmware upgrade there is a special mode **active force**. The command is not saved in the configuration and acts as a signal for all units to send their requests for upgrade regardless the work mode and information accumulation time period.

If during the process of new firmware distribution an error occurs (or link loss) the passive unit will stop the upload process and will resend its request after getting an announcement.

Examples:

The unit is in the active mode sending announcements about new firmware version. If units with newer firmware version are found on the network, the

upload request will be sent in no less than 7 hours after uninterrupted work of the announcement source:

```
mint rf5.0 -airupdate active normal
```

The unit is the passive mode waiting for the source of the latest firmware version to work with it during no less than 24 hours:

```
mint rf5.0 -airupdate passive slow
```

The operator decides to immediately upgrade all the units with new firmware:

```
mint rf5.0 -airupdate active force
```

The unit is not participating in AirUpdate process. It does not send announcements and does not generate requests for upgrades:

```
mint rf5.0 -airupdate disable
```

3.2.5 Over-the-Air Encryption

All MINT protocol messages are automatically encrypted. This feature is always turned on.

Both AES-128 CCMP hardware encryption and proprietary software encryption are supported on the device.

Proprietary encryption has the following features:

- Each node has its own key (should not be specified in the configuration) for outgoing traffic encryption
- There is no restrictions on the number of nodes that use outgoing traffic encryption in the MINT network
- Every three minutes the key is dynamically changed

For full data encryption the following command is used:

```
mint IFNAME -[no]crypt [aes]
```

The command turns on/off over-the-air encryption. Encryption is proprietary with the following features:

- Each node has its own key (should not be specified in the configuration) for outgoing traffic encryption

- There is no restrictions on the number of nodes that use outgoing traffic encryption in the MINT network
- Every three minutes the key is dynamically changed

Example:

```
mint rf5.0 -crypt
mint rf5.0 -crypt aes
```

3.2.6 Learning the Connection

The following command is used to learn the state of the connection:

```
mint IFNAME map [routes | full | swg] [detail] [-n] [-m]
mint -[no]colormap
```

Three options are used:

- The following output is displayed:

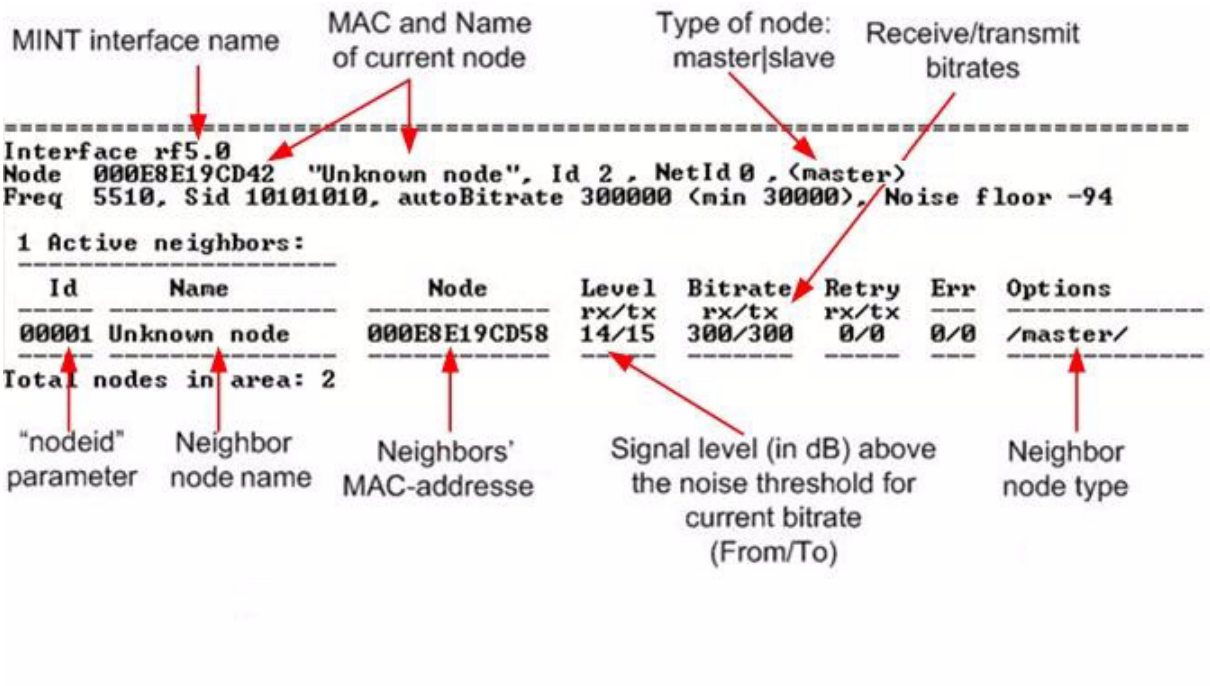


Figure 3-1: Mint Map Output

- Routes. The following output is displayed:

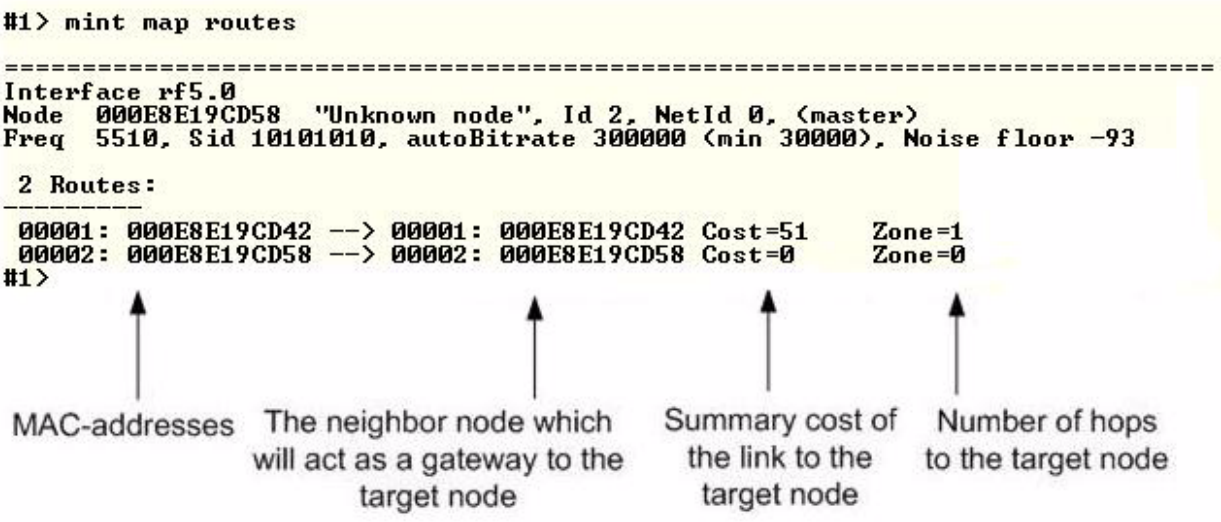


Figure 3-2: Mint Map Routes Output

- Full. A combination of the above modes

- Swg. This option is used when switching groups are created in MINT network. It shows in which switching groups neighbor node is included:

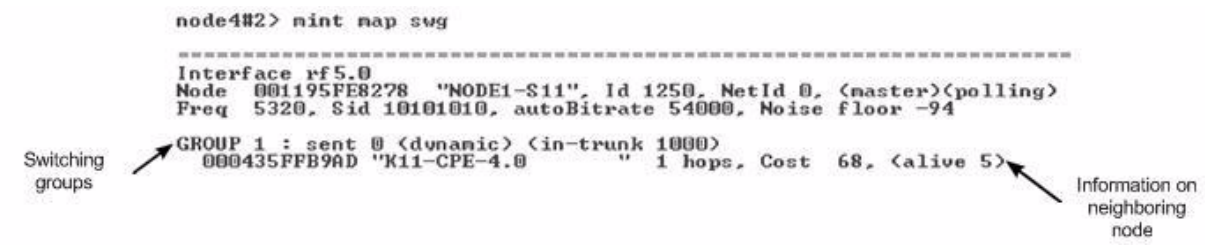


Figure 3-3: Mint Map Swg Output

Parameters:

- -**detail** - shows the following information for each link with a neighboring node: distance do the neighboring node in kilometers, load on receive/transmit in Mbps, on receive/transmit in packets per second, link "Cost", main IP-address of the neighboring node.

- -**n** - with **Routes** and **Full options** replace nodes MAC-addresses with nodes names.

- -**m** - shows I/O signal levels relative to minimal receive/transmit bitrate. (Without -**m** relative to current bitrates).

Mint -**[no]colormap** option enables/disables color indication of the command:

- **Common color** identifies neighbor nodes that have acceptable characteristics of a link to the current node.
- **Yellow color** identifies neighbor nodes that potentially may have problems with sustainability and quality of a link to the current node. In this case link quality can be improved through the change of certain parameters (for example, lowering bitrates).
- **Yellow color with red background** identifies neighbor nodes that have unsatisfactory characteristics of a link to the current node. For example, neighbor nodes that have low characteristics of a link on the lowest possible bitrate or have errors are marked this way. In this case link quality can be improved by such actions as antenna alignment, cable connectivity testing and so on.

When neighbor nodes are marking with certain color style it is not only signal level but also number of retries and errors are taken into consideration.

3.2.7 Continuous Signal Levels Monitoring

Syntax:

```
mint IFNAME monitor [-screen] [-i SECONDS] [MAC [MAC ...]]
```

If no MAC-addresses are specified, the output of command will contain the information about all neighbors and candidates of the current node.

Instead of MAC-addresses "nodeid" and/or "name" of the node can be specified.

The sample output of the command is presented below.

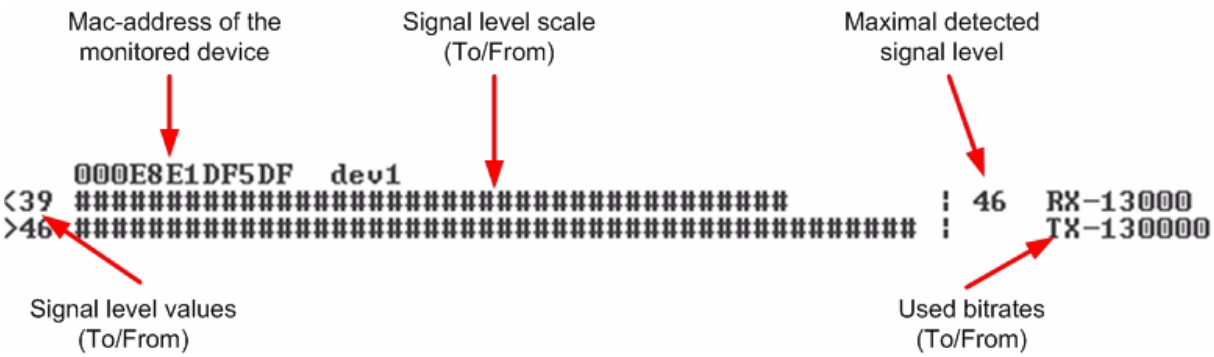


Figure 3-4: Mint Monitor Output

"**screen**" option keeps the output within one screen without line-by-line output

"-**i SECONDS**" set the interval for information output in seconds

3.2.8 Frequency Roaming

For a flexible management of frequency resource, higher noise immunity and throughput optimization equipment supports frequency roaming capability based on MINT protocol.

Roaming is turned off by default - that means that the unit works using fixed radio interface configuration.

Any node of the network can be set up as a **roaming leader**. Roaming leader will define required radio frequency parameters of the wireless network. Roaming leader also works with a fixed radio interface parameters, however its radio parameters configuration is transmitted over the network in special packets so other node of the network knows whether it is connected to the roaming leader. Roaming leader also supports DFS and Radar Detection features (if a special license is installed for selected countries).

A network node can use roaming in order to search for the roaming leader. The search is implemented by switching between different sets of radio parameters that are defined in profiles. Each profile contains a fixed set of radio interface parameters which are set on each iteration of the search.

Profile parameters:

- **freq XX[,YY,..]** - radio interface frequency or list of frequencies. Auto keyword can be used - in this case all frequencies that the unit supports will be used.
- **sid XX[,YY,..]** - SID of the radio interface (or list of SIDs)
- **bitr XX** - bitrate of the radio interface. Acts as a top limit for the bitrate if autobitrate mechanism is turned on
- **band {double|full|half|quarter}** - defines the channel width for the profile. If profiles use different channel widths, auto mode for frequency cannot be used
- **type {master|slave}** - node type
- **key XXX** - secret key
- **nodeid N** - node ID

- **[-fixedbitr]** - sets fixed bitrate for the node
- **[-minbitr XXX]** - minimum bitrate for operation in "autobitrate" mode
- **[-autobitr [+/-dB]]** - operation mode with automatic bitrate control. [+/-dB] parameter allows to manage bitrate control sensitivity.
- **[enable | disable | delete]** - enables, disables or deletes the profile.

Syntax:

```
mint IFNAME profile N [-freq XX[,YY,..] | auto] [-sid
   XX[,YY,..]] [-bitr XX]
            [-band {double | full | half | quarter}]
            [-type {master|slave}] [-key XXX] [-nodeid N]
        [{-minbitr XXX [-autobitr [+/-dB]] | -fixedbitr}]
            [enable | disable | delete]
mint IFNAME roaming {leader | enable | disable}
```

Samples:

```
mint rf5.0 profile 1 -freq 5920 -sid ABCDE
mint rf5.0 profile 2 -freq 5960 -sid ABCDE disable
mint rf5.0 roaming enable
```

3.2.9 Remote Command Management

Remote command management allows one MINT node to perform commands on one other or all MINT nodes in the network.

Options:

- **-rcmdserver {disable | enable}** - disables/enables remote control management mode (enable by default)
- **-guestKey STRING** - guest key. Guest key allows to perform read only commands on the node
- **-fullKey STRING** - full key. Full key grants full access to the node (all commands can be performed)

- **-node {ADDR|all}** - Mac-address of the destination node or access to all MINT nodes
- **[-local]** - performs commands only on the node that is connected to the given device
- **{-cmd "CMD" | -file URL}** - command to be performed or root to a command file by ftp
- **[-key KEY]** - access key
- **[-quiet]** - disables writing replies from remote devices to a system log.

Syntax:

```
mint IFNAME rcmd -node {ADDR|all} [-local] {-cmd "CMD" |
   -file URL} [-key KEY] [-quiet]

mint IFNAME -rcmdserver {disable | enable} -guestKey STRING
   -fullKey STRING
```

Samples:

```
mint rf5.0 rcmd -node all -cmd "co sh"

mint rf5.0 rcmd -node all -file
   ftp_name:ftp_pswd@192.168.100.21/1.txt
```

3.3 Ltest (Radio Link Test)

Test of a radio link. It is recommended for antenna alignment when installing a new device or for testing of existing radio link.

Syntax:

```
ltest IFNAME target [-r rate[,reply_rate]] [-s
   packet_size[,reply_size]] [-b] [-p priority] [-a (l|r|m)]
   [-auto (l|r|m)] [-align [N[,R]]] [-tb [seconds]] [-tu
   [seconds]] [-load N[m|k] [-mint]ltest -key [PASSWORD]

ltest -noauto

ltest -stop

ltest (-disable|-enable)
```

Description:

- **IFNAME** - radio interface on which testing will be performed
- **target** - MAC-address of a target device on the other side of a tested radio link
- **-r rate[,reply_rate]** - sets bitrates for transmitting test packets from the local device and toward it. This parameter is optional. There are two situations when this parameters are not configured:
  - » Local device is tested with its neighboring node, i.e. we can view remote device and **tx/rx bitrate** values for it in a "**mint map**" command output. In this case **tx/rx bitrate** values from "**mint map**" command output are taken for **rate** and **reply rate** parameters.
  - » Local device doesn't consider remote device as a neighboring node. In this case **rate** and **reply rate** parameters will be equal to minimal possible **bitrate** of the local device for current bandwidth (for example, 6 Mbps for 20 MHz bandwidth, 3Mbps for 10 MHz, 1.5 Mbps for 5 MHz).
- **-s packet_size[,reply_size]** - establishes test packet size from the local device and toward it. Test packet size by default is 1024 bytes. Maximal possible test packet size is 1810 bytes.
- **-b** - transmitting broadcast test packets

- **-p** - sets priority level to "ltest" packets (from 0 to 16). No priority is set by default.

- **-key [PASSWORD]** - sets password for testing. If two devices have different passwords they can't perform testing with each other

- **-noauto** - disables automatic test after device reboot, i.e. test won't stop immediately, but after device reboot it won't start

- **-stop** - stops the test almost immediately

- **-disable|-enable** - disables/enables ability to perform link test. Enable by default

- **-align [N[,R]]** - special "ltest" command mode for antenna alignment. It allows aligning each antenna of the device independently. *N* parameter sets which antenna will be used to transmit test frames from the local device. *R* parameter sets which antenna will be used to transmit test frames from the remote device fro the other side of the link. If *N* parameter is not specified then average signal level value between two antennas will be shown. If *-r* is not specified then test can be performed even when only one antenna is attached to each side of the link. If *-r* is specified then *N* and *R* parameters are ignored.

  N and *R* parameters can have the following values: 0 - antenna with vertical polarization, 1 - antenna with horizontal polarization.

All parameters (including specified by default) keep its values the same as they were at the beginning during the whole test.

Examples:

```
lt rf5.0 00179AC2F3E6
```

This command illustrates the simplest way to start link test. "**lt**" command with all parameters undefined (default parameters) starts test of a local device with a remote device which have "00179AC2F3E6" MAC-address.

```
lt rf5.0 00179AC2F3E6 -r 39000
```

This command starts link test with **rate** parameter 24 Mbps. In this case **reply rate** parameter will be taken by default.

"ltest" command recommendations:

When "**ltest**" command starts it will show you output information that contains testing results (except **auto** mode). You can see command output below:

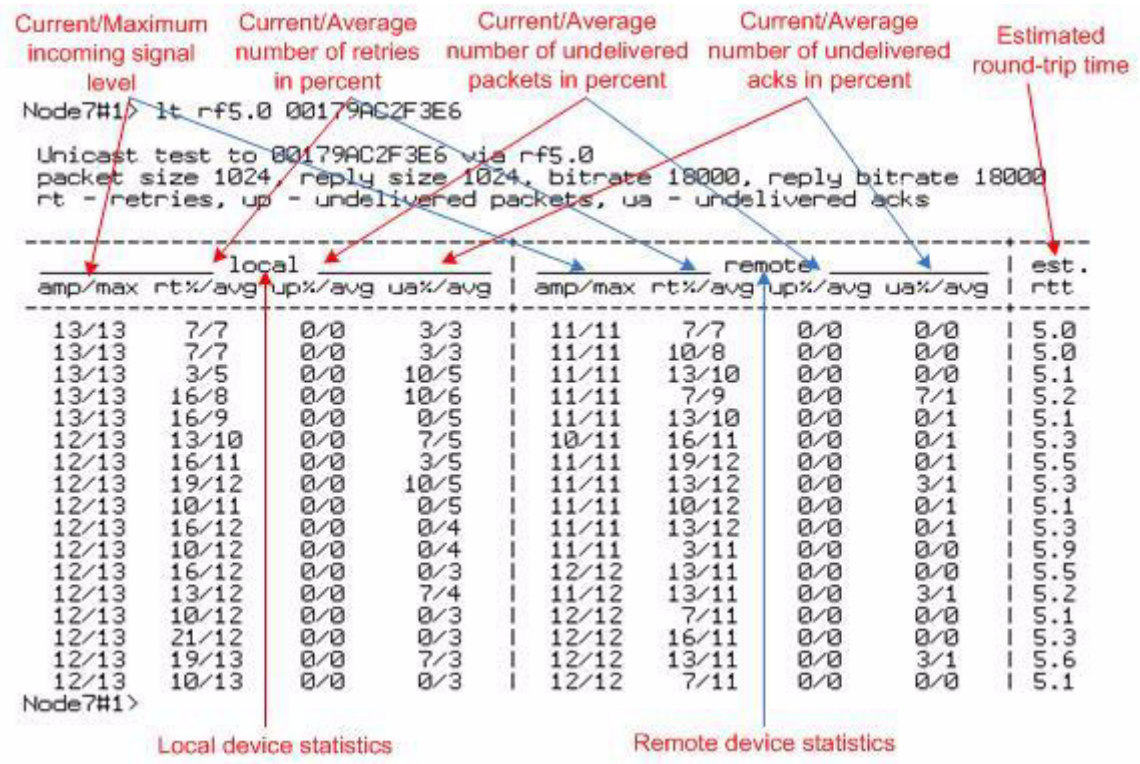


Figure 3-5: Ltest Output

"**ltest**" output when using the "*-align*" parameter:

```
Unicast test to 000E8E1DF5E1 via rf5.0 with no priority
packet size 1024, reply size 1024, align, tx antennas: local(0), remote(1)
rt - retries, up - undelivered packets, ua - undelivered acks

-----------------------------------+-----------------------------------+-----
_____________ local _____________ | _____________ remote _____________ | est.
ant.amps rt%/avg up%/avg ua%/avg | ant.amps rt%/avg up%/avg ua%/avg | rtt
-----------------------------------+-----------------------------------+-----
14:43:00   0/0     0/0     0/0   | 44:15:00   0/0     0/0     0/0   | 6.6
```

Figure 3-6: Ltest Align Output

The difference of this output from the standard one is that "ant.amps" column is used instead of "amp/max". "Ant.amps" column indicates signal levels from 0, 1 and 2 antennas divided by ":" correspondingly.

For success radio link establishing the following factors have to be considered:

1. It is recommended to start antenna alignment with searching maximum signal level on a minimal possible bitrate. Afterwards automatic MINT mechanisms will set the most appropriate bitrate if autobitrate mode will be enabled.
2. Current incoming signal level in "amp/max" columns (see "ltest" command output) must be between 12 and 40.

   When it is more than 40 it is recommended to lower amplifier power.

   If maximal signal level is less than 12 it is recommended to lower bitrate or channel width (for example, from 20MHz to 10MHz on the both sides of the radio link).

   In some cases signal level that is less then 12 may be enough for radio link operation. In this case one has to be guided by such parameters as number of retries, number of undelivered packets and number of undelivered acks. If the number of undelivered packets and the number of undelivered acks is null, the number of retries is small and all these parameters are constant in time then the radio link, most often, will be operating properly.
3. Number of retries value in "rt%" columns must be as close to zero as possible.
4. Number of undelivered packets value in "up%" columns must be zero; if this value is not zero then the radio link couldn't be exploit.
5. Number of undelivered acks value in "ua%" columns must be zero; if this value is not zero then the radio link couldn't be exploit.

ALL described parameters must be observed in the both (**Local** and **Remote**) sections of the "**ltest**" command output.

Radio link bandwidth test (Bandwidth meter):

Bandwidth meter is used to test the following radio link characteristics: speed in kilobits per second, speed in packets per second, number of retries and errors.

Use the following "ltest" command options for testing:

- -**tu [seconds]** - Unidirectional test: packets are transmitted only fro the current side to the specified address ("target" option)
- -**tb [seconds]** - Bidirectional test: packets are transmitted in both directions

Packet size by default - 1536 bytes (to change packet size use "-s" option).

"*Seconds*" parameter allows setting test period (5 seconds by default). Maximum value is 60 seconds.

-load N[m|k] option allows setting a limit on the maximal tested channel bandwidth. By default, N parameter is measured in Megabits per second. If *k* parameter is specified then in kilobits per second (for example, 10m - 10 Mbps, 500k - 500 Kbps).

When **[-mint]** option is specified bandwidth test will be done with the help of MINT network.

This option is available only with *-tu* or *-tb* options. When using *-mint* option *-r* option is ignored.

"Ltest" command output in Bandwidth meter mode:

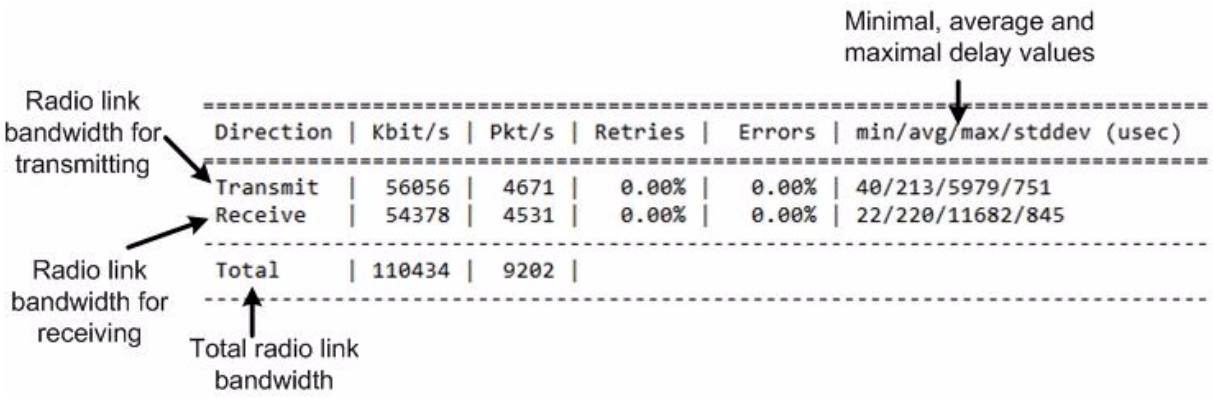


Figure 3-7: Ltest Bandwidth Output

Example:

```
lt rf5.0 00179AC2F3E6 -tb
```

This command starts bidirectional link bandwidth test of a local device with a remote device which have "00179AC2F3E6" MAC-address.

3.4 Muffer Command (Environment Analyzer)

The muffer module is used to analyze the electromagnetic environment.

Syntax:

```
muffer IFNAME [-tXX] [-lXX] review [FREQ1 [FREQ2 ...]]
                            | sid | { mac[2|3]|mynet|scan [MAC]}
muffer IFNAME sensor [F1 [F2] [BW STEP]]
muffer stat [clear]
```

Description:

The **muffer** module makes it possible to rapidly test the electromagnetic environment, visually estimate the efficiency of the utilization of the air links, reveal sources of interference, and estimate their power.

Several operating regimes of the **muffer** module provide for different levels of details in test results.

3.4.1 Review Mode

This regime is enabled by the **review** option. It makes possible to have a general estimation of emissions and interference within specified frequency range. Up to 7 frequencies (separated by spaces) subject to analysis may be specified as parameters [FREQ1 [FREQ2 ...]. Only two last digits of the frequency values shall be given.

CAUTION

Normal operation of a radio module is impossible when this regime is enabled.

Example:

```
muffer rf5.0 review
```

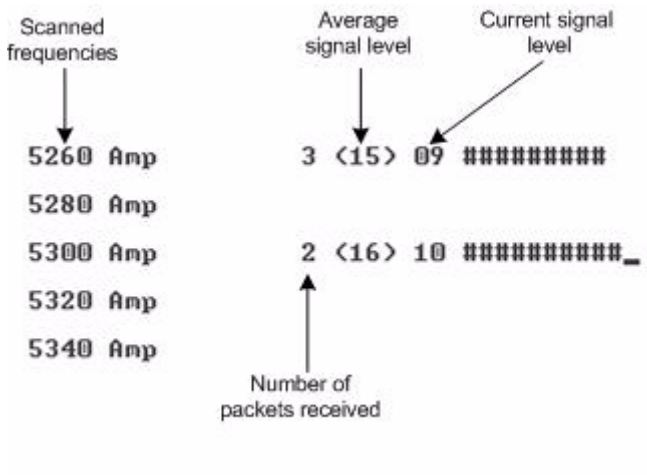


Figure 3-8: Muffer Review Mode

The picture above shows the output of the review mode.

3.4.2 SID Mode

The **sid** regime allows estimating the number of currently operating client groups having different identifiers (SID), and the efficiency of air links utilization. The analysis is carried out for all network identifiers at the frequency previously specified for the radio module by **rfconfig** command.

Example:

```
muffer rf5.0 sid
```

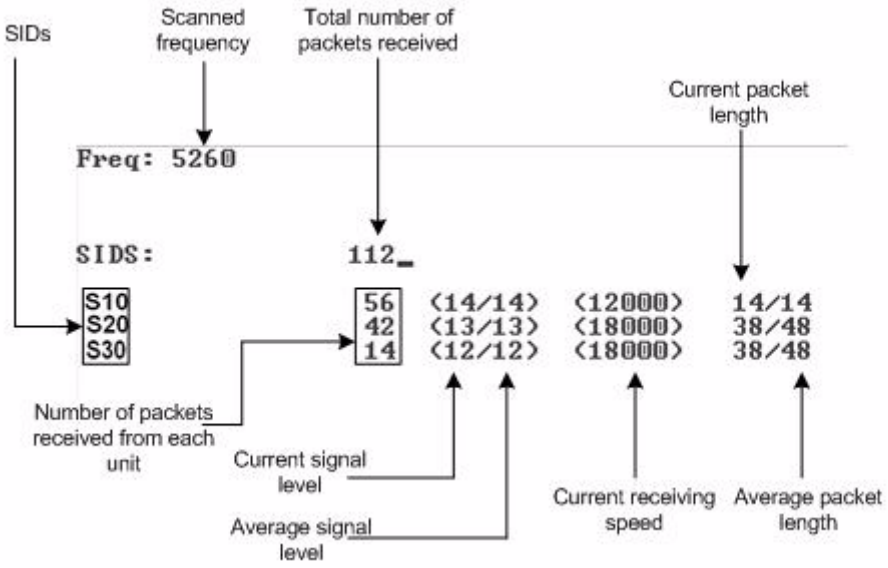


Figure 3-9: Muffer SID Mode

3.4.3 MAC|MAC2|MAC3|MYNET modes

These modes perform the efficiency of their utilization of the air link. The analysis is carried out for all MAC-addresses at the frequency previously specified by rfconfig command. **[MAC]** option allows carrying the air link analysis in MAC | MAC2 | MAC3 | MYNET modes for the specified MAC-address.

The **mac** mode checks only data packets, while in the **mac2** mode the link-level ACK messages sent by protocol support devices are also taken into account whenever possible. Compared to **mac2** mode, **mac3** mode also performs calculation of impulse interference. It shows number of detected pulses, their average signal level and pulses per second information.

Finally, the **mynet** regime performs the radio testing without disturbing radio module's normal operation.

Example:

```
muffer rf5.0 mac2
```

The picture below shows the output for **mac2** regime.

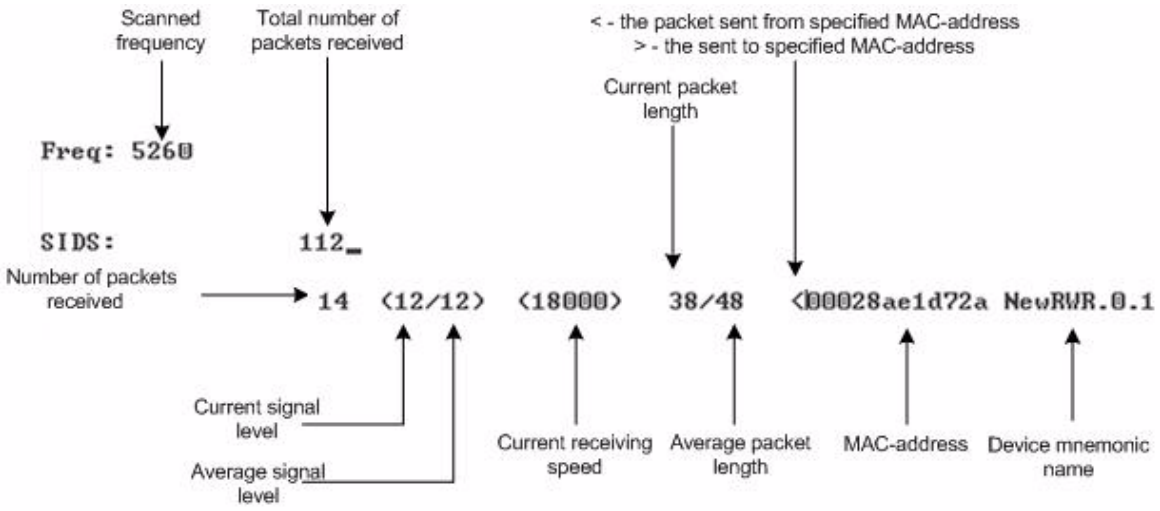


Figure 3-10: Muffer MAC2 Mode

3.4.4 Scan Mode

The scanning regime is enabled by a **muf scan** command, and provides for deep analysis of radio emission sources within the given network's territory. In this regime, the device scans the radio spectrum on all frequencies and for all modulation types. **[MAC]** option allows carrying the air link analysis for the specified MAC-address.

Information is displayed on any source of irregular (non-repetitive) radio signals.

To obtain information as complete as possible, the scanning process may take significant time.

CAUTION

Normal operation of the radio module is impossible when the scan regime is enabled.

Example:

```
muffer rf5.0 scan
```

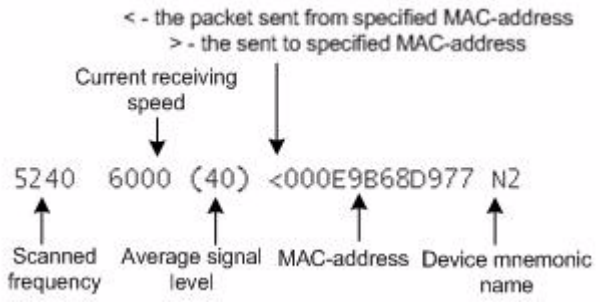


Figure 3-11: Muffer Scan Mode

Supplementary options for all the above regimes:

- -**tXX** specifies the duration of time, in seconds, for which the test regime is enabled (2 minutes by default). The value 0 in this field enables a test regime for unlimited time.

- -**lXX** specifies the number of lines on the screen for displaying test results (24 lines by default)

To terminate the analyzer operation in any of the above regimes, press **<ESC>** or **<Ctrl/C>**.

3.4.5 Statistics Module

The statistics gathering is used for estimating link load intensity. The amount of packets sent and received, and the number of retransmissions is shown for each MAC-address participating in the data exchange.

The statistics output is presented in the picture below.

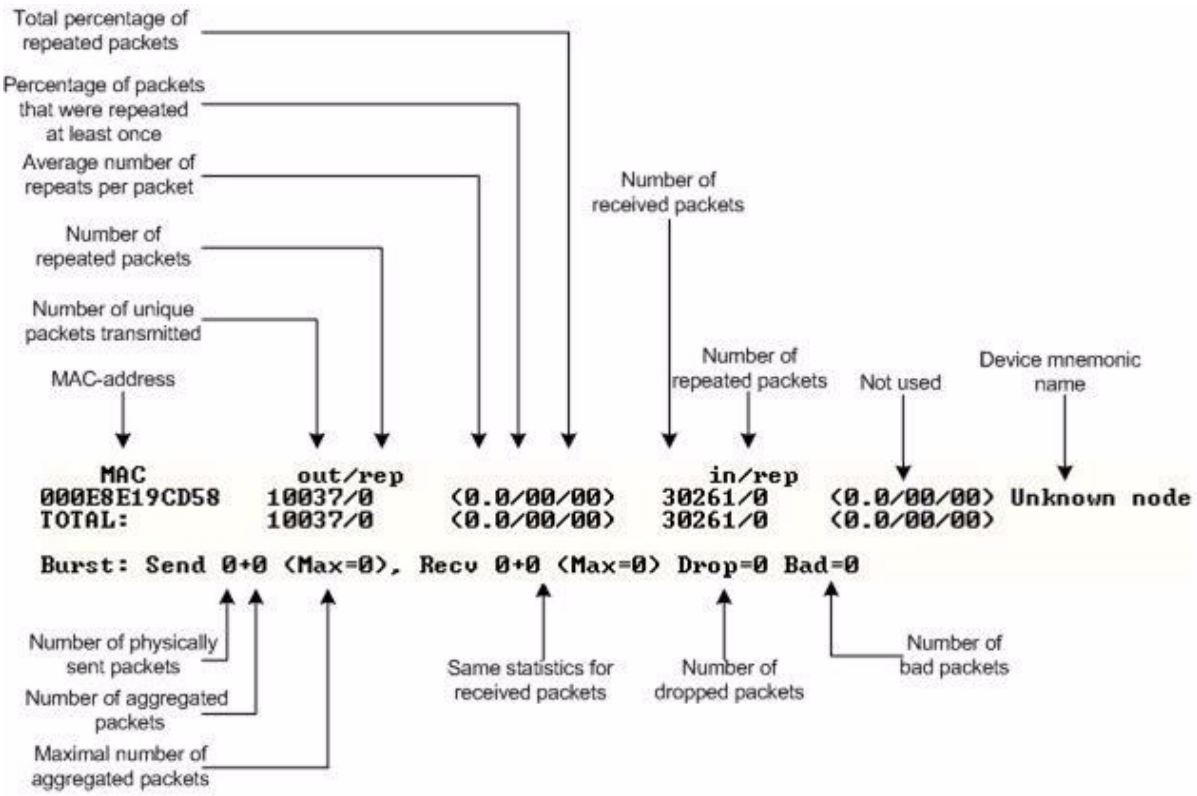


Figure 3-12: Muffer Statistics Module

The following decisions can be made by analyzing the outputted parameters:

- If the number of repeated packets is comparable with total number of packets that means that you might have an interference source on the selected frequency. For normally operating link the percentage of repeated packets should not exceed 10%. It is extremely important to obtain a permanent zero value for the average number of repeats per packet. If the value is not zero that means that the link is NOT working properly and requires further improvement

- If total percentage of repeated packets and the percentage of packets that were repeated at least once are close to each other that might mean that you have got a permanent source of interference. Otherwise, it means that a strong interference source appears from time to time breaking your signal

- Concerning the fact that statistics module outputs the information for each MAC-address separately, you can reveal the problem for some specific unit on the wireless network

The "**muffer stat**" command shows the statistics only from registered devices.

To view **statistics** type the following command:

```
muffer stat
```

To reset all counters please type

```
muffer stat clear
```

3.4.6 Spectrum Analyzer Mode

The Spectrum Analyzer mode is enabled by a muf sensor command and provides deep analysis of radio emission sources. In this mode device scans the radio spectrum on all available frequencies.

Information is displayed on the screen in a visual-digital format.

To obtain information as complete as possible, the scanning process may take some time.

NOTE

It is recommended to use Graphical Spectrum Analyzer in Web-interface (please see "Technical User Manual" for instructions).

CAUTION

Running Spectrum Analyzer mode disturbs normal operation of the radio module and makes it impossible to access the unit via radio.

Example:

```
muffer rf5.0 sensor
```

The picture below shows **muf sensor** output:

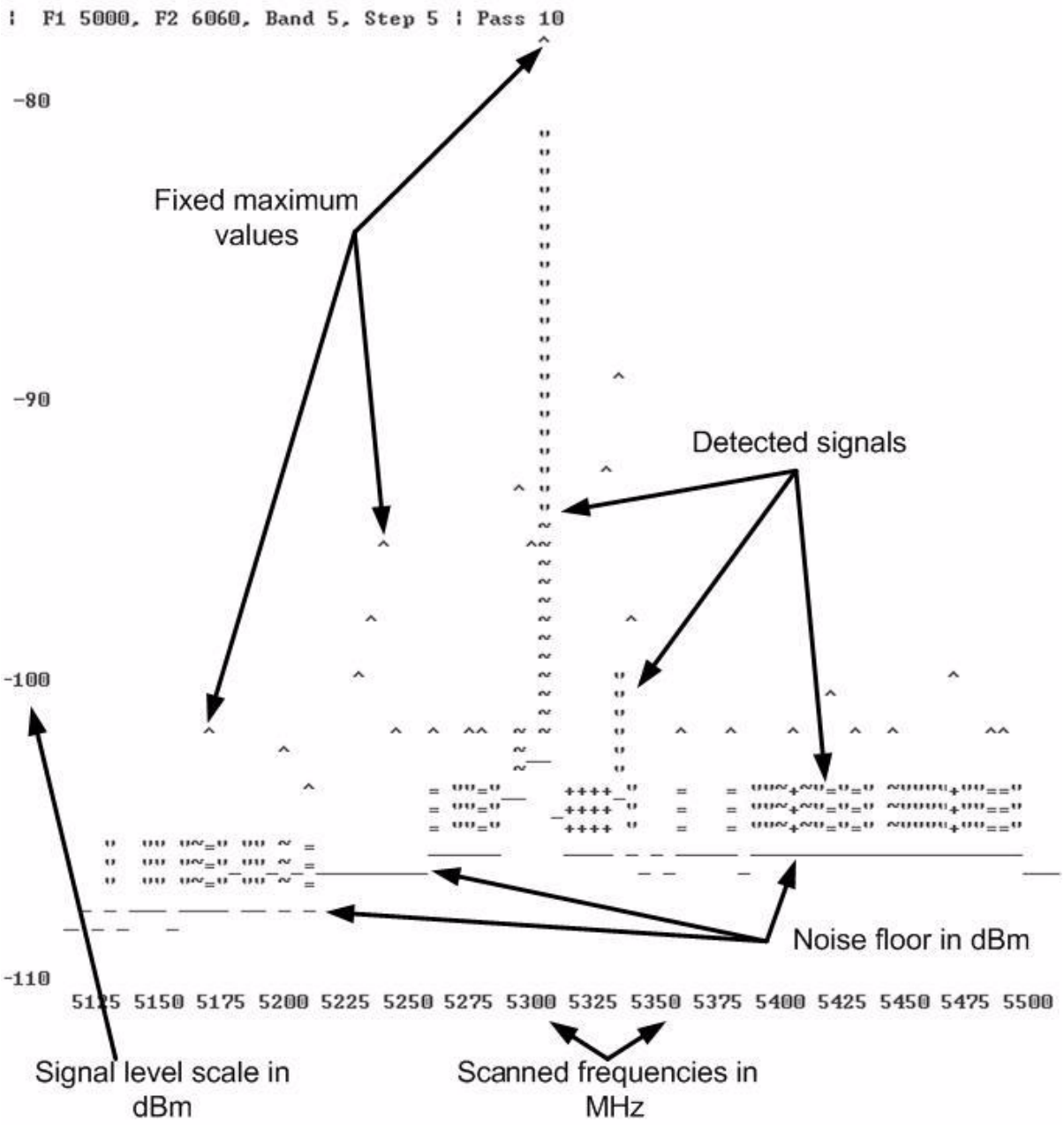


Figure 3-13: Muffer Spectrum Analyzer Mode

Supplementary options for "muf sensor" command:

- **F1** - sets the initial frequency for scanning in MHz. Minimal available frequency for the given equipment model is used by default.

- **F2** - sets the ending frequency for scanning in MHz. Maximal available frequency for the given equipment model is used by default. The actual shown ending frequency is limited by the size of the program window.

- **BW** - sets bandwidth in MHz. Allowed values are 1/5/10/20 MHz depending on the concrete equipment mode.

- **STEP** - sets frequency changing step in MHz. Allowed values are 1/5/10/20 MHz but no more than defined bandwidth value.

To terminate the analyzer operation in any of the above modes press **<ESC>** or **<Ctrl/C>**.

3.5 Arp Command (ARP Protocol)

Implementation of Address Resolution Protocol.

Syntax:

```
arp view [IP]
arp add IP MAC|auto proxy
arp del IP|all [proxy]
arp [-]freeze
arp [-]proxyall [$ACL]
```

Description:

ARP protocol serves for IP to MAC-address mapping and vice versa. For example in Ethernet it allows to transform IP destination address into its 48-bit Ethernet address for packet forwarding over LAN.

In common case ARP works automatically making address resolution as it is necessary. But there are some cases when ARP tables should be corrected manually and **arp** command solves this problem.

The command has several forms:

```
arp view [IP]
```

Displays ARP records for IP-address. Displays all ARP records if address is not specified.

```
arp add IP MAC [proxy]
arp add IP auto proxy
```

Adds record into the ARP table. MAC-address mapped to IP-address. If keyword proxy specified then the system will announce this information as response to the requests from other stations, acting as proxy ARP server - even if this IP-address is not system own address. In this case instead of MAC-address one may specify auto keyword.

```
arp del IP | all [proxy]
```

Deletes the record for IP. Or all records in the system if keyword all specified. If optional parameter proxy specified, then only proxy IP-addresses will be deleted.

```
arp [-]freeze
```

Enables to freeze ARP table. No more automatically updates allowed. The command fixes only manual records and does not affect on the radiointerface with active protocol MINT. Be careful when entering this command via telnet.

```
arp [-]proxyall [$ACL]
```

In **proxyall** mode the system will reply on all ARP requests, if respective IP target address resides in the routing tables and reachable via interface other than source MAC-address. I.e. if there is a route to the target IP then the system can be considered as a gateway.

In **proxyall** mode, you can specify an **$ACL** list of addresses/networks which limits replied ARP requests of the command with networks and addresses of the **$ACL** list.

Example:

```
arp add 10.10.10.10  00:11:22:33:44:55
arp add 192.168.5.1  5544332211 proxy
```

3.6 Macf Command (Addresses Mapping)

The command is used to map IP-addresses onto Ethernet MAC-addresses

Syntax:

```
macf MAC-address IP-address Comment

macf del N

macf [-]dhcp [-]strict | [-]reverse | [-]simple [-]quiet

macf show | clear
```

Description:

The **macf** command performs static mapping of IP-addresses to MAC-addresses in an Ethernet network. It may be useful for service providers when they connect to their network a group of clients (such as individual users in an apartment block) via one common access unit. In this case, clients may be tempted to change their IP-address to that of a neighbor, thus deceiving provider's accounting system. Although it is almost impossible to definitely resolve this issue, you can make however your life easier by directly mapping the client's assigned IP-address to his/her MAC-address, because surreptitiously modifying a MAC-address is much more difficult for an average user.

Every **macf** MAC-address IP-address command adds a new address pair to the address mapping table:

```
macf 102030405060 1.1.1.1 Room123

macf 203040506070 2.2.2.2 Room125
```

The comment parameter is a simple description string with no syntax restrictions.

The current state of the mapping table may be displayed by a **macf show** or **co show** command:

```
macf show
```

The output is the following:

```
macf 1 0020af915099 192.78.64.99 Server

macf 2 0020af9150a3 192.78.64.194 Room94

macf 3 0020af9150a4 192.78.64.134 Room57

macf 4 0020af9150a7 192.78.64.174 Admin
```

The second column in the above table contains automatically assigned internal numbers, which may be used to delete any specific line from the table by a **macf del N** command.

The **macf clear** command clears the mapping table altogether.

Quiet option allows switching off message logging to the system log.

The mapping filter may operate in two different regimes:

In the **normal regime**, all client units whose address pairs are not explicitly specified in the mapping table are treated as usual, without any restrictions. This is default regime.

In the **strict regime** (which is enabled by macf strict and disabled by **macf -strict**), all packets received from units not described in the mapping table will be discarded.

CAUTION

If you are remotely configuring a device using telnet, make sure, when enabling the strict regime, that your own workstation is already cited correctly in the mapping table. Otherwise you lose control over the device, and disabling the strict regime will be only possible through the devices's diagnostics port.

In both regimes, when a packet is discarded by the filter, this fact is accompanied by a warning message on the screen and registered in **syslog**. To prevent an avalanche of faulty registration packets, only the first attempt to deceive the system from the group of similar ones is registered.

The MAC filter algorithm consists of two steps. In the normal mode (**default**):

1 First, the table is searched for the MAC-address of a packet being checked.

2 If the MAC-address is found, then the received IP-address is checked for correspondence with that found in the table.

The reverse mode (enabled by **reverse** option, and disabled by -reverse) swaps the above two steps:

1 First, the table is searched for the IP-address received

2 Then the MAC-address received is checked against that from the table.

In both regimes, the parameter with which the search starts is a search key and cannot appear in the table more than once.

If the **simple** option is enabled, only the first step of the above algorithm is executed. If the address searched for is found in the mapping table, then the packed is normally handled by the device. Otherwise, the packet will be discarded,

regardless of whether the **strict** option is enabled or not (the second address is not checked).

With **dhcp** option enabled, macf filter is automatically supplemented with addresses issued by local DHCP server. These records are not stored in a permanent configuration and work until the given address is deleted by DHCP server.

Hereafter, some possible scenarios of using different filtering options:

1. **Flat model**. All workstations of the client's local network are directly connected to the Ethernet interface of the device. In this case the simpliest filtering may be used, possibly with the strict option enabled:

   ```
   macf MAC-address IP-address [strict]
   ```

2. If an intermediate device is installed between a client unit and the client's LAN, then **reverse strict** or **reverse simple** modes may be used, with IP-addresses of all authorized workstations being directly listed in the mapping table, while the MAC-address is always that of the intermediate device.

3. If several LANs are connected to the same device, each through an intermediate device, then the simple or reverse strict modes may become the most useful, with MAC-addresses of all those intermediate devcies being listed in the mapping table.

3.7 Switch Command

This command is used to configure MAC Switch.

Syntax:

```
________ LIST commands _____________________________________
switch list LISTNAME [{iface | mac | numrange | match}]
       {add | del} [VALUE ...]
       dump [WILDCARD]
       rename  NEWNAME
       file   FILENAME
       [ flush|remove]
________ GROUP commands _____________________________________
switch group GROUPID {add | del} IFNAME[:{TAG|0}] ...
switch group GROUPID {repeater|trunk}    {on|off}
switch group GORUPID {(up|down)stream} {SCID|0}
switch group GROUPID vlan {TAG|LIST|0}
switch group GROUPID xvlan {TAG|LIST|0}
switch group GROUPID info INFO_STRING
switch group GROUPID setid NEWGROUPID
switch group GROUPID stp { off | on | dump }
switch group GROUPID stp priority [PRIO] #(default: 57344,
   step: 4096)
switch group GROUPID stp forwarddelay [DELAY] #(default: 15
   sec)
switch group GROUPID stp maxage [TIME] #(default: 20 sec)
switch group GROUPID stp port IFNAME priority [PRIO]
   #(default: 128,step 16)
switch group GROUPID stp port IFNAME cost [COST] #(default:
   200000(RSTP), 5535(STP))
switch group ID igmp-snooping { off | on }
switch group ID order N
```

```
switch {group ID | interface IFNAME}
      [ setpri|addpri prio ]
      {deny | permit | showrules}
switch group GROUPID
       [dump [interface] | showblack] [WILDCARD]]
       [dbdelete   MACADDRESS]
       {start | stop | remove}
switch group GROUPID in-trunk [{GROUPID|0}]
switch admin-group {GROUPID|0}
_________ RULES commands ____________________________________
switch {group GROUPID | interface IFNAME} rule NUMBER
       [set NEWNUMBER]
       [src   LIST] [dst   LIST] [vlan  LIST]
       [iface LIST] [proto LIST] [match LIST]
       [ setpri|addpri prio ]
       [ deny | permit ]   [ remove ]
________  CONTROL commands ___________________________________
switch keeptag [(on|off)]
switch resynchronize
switch local-tag TAG
switch trace { off | on | verbose }
switch stptrace { off | on }
switch {dump [WILDCARD]|MACADDRESS}
switch igmp-snooping dump [detail]
switch igmp-snooping lmqt Value
switch igmp-snooping gmi Value
switch igmp-snooping static-add MCAST IF_NAME [MAC]
switch igmp-snooping static-del MCAST IF_NAME [MAC]
switch igmp-snooping querier group N [source X] [mcast X]
   [vlan N] {start|stop}
switch {start | stop | restart | dead-interval DEAD_INTERVAL}
```

3.7.1 Wildcard Format

Wildcards are used in different commands to filter printed information. As a difference from standard wildcards, in special cases the following characters can be used:

- * - any number of any symbols (or empty).
- ~ - any symbol (just one).

Example:

```
rf~.~
```

This filter includes the strings like rf5.0, rf5.1 etc.

3.7.2 List Configuration Commands

Syntax:

```
switch list LISTNAME [{iface | mac | numrange | match}]
       {add | del} [VALUE ...]
       dump [WILDCARD]
       rename  NEWNAME
       file   FILENAME
       [ flush|remove]
```

Lists are used as a set of acceptable values for **rules**. Each list must have a unique name and must be of one of the types: iface, mac, numrange, match. List name may consist of letters and digits. List name should not start with a digit. List name is case-insensitive.

Command parameters:

- **LISTNAME** - list name. If list name contains spaces, it should be put in quotes.
- **iface** - list type which consists of network interfaces names.
- **mac** - list type which consists of a set of MAC-addresses
- **numrange** - list type that consists of a set of ranges of positive integer numbers. The range of numbers is specified as **<min>[-<max>]**. The range

may consist of one number if <min>=<max>. If a range of numbers is added to existing list and two ranges values intersect, these ranges will be concatenated.

- **match** - by context, match expressions are identical to expressions lists but should consist of one element - the expression itself.

Keywords **add** and **del** add or delete values to the specified list correspondingly.

VALUE - one or several (except for **match**) values to be added or deleted from the list.

Examples:

```
switch list my_iface iface add eth0 rf5.0
```

Here a list of **iface** type is created with a name of **my_iface**. Interfaces eth0 and rf5.0 are added to this list.

```
switch list vlans numrange add 10 20-30 40
```

A range of numeric values are added to a list with a name of **vlans** and with a type of **numrange**. Values added are 10, the range from 20 to 30 and a value 40.

```
switch list ip_mynet match add 'net 195.38.45.64/26'
```

A list-expression of **match** type is created. In this case when using filter its effect will cover all types of packets (ip, arp and so on) from 195.38.45.64/26 network.

```
switch list ip_mynet match add 'ip net 195.38.45.64/26'
```

In this example a list-expression of **match** type is also created but now only ip packets from 195.38.45.64/26 network will be affected when using filter.

A source file can be specified for the list. The source file should contain the list of values with each value taking one line. The file is retrieved using FTP protocol.

Example:

```
switch list MACGROUP1 file
   ftp://1.2.3.4/switches/list/macgroup1.txt
```

With this macgroup1.txt file might contain the following information:

```
#The list of computers in HR department

00:01:02:03:04:05# Smith

00:11:12:13:14:15# Johnson

<EOF>
```

Values are loaded from the file automatically after switch is started, or when a source file name is modified or when the following command is executed:

```
switch synchronize
```

```
switch list LISTNAME remove
```

This command deletes the list with LISTNAME name from the switch configuration.

```
switch list LISTNAME flush
```

Clears the contents of LISTNAME name.

```
switch list OLDLISTNAME rename NEWLISTNAME
```

Renames the list with OLDLISTNAME to NEWLISTNAME.

```
switch list LISTNAME  dump [WILDCARD]
```

Prints the contents of the list LISTNAME. If WILDCARD parameter is specified, the command prints only those values from the list which satisfy the WILDCARD.

3.7.3 Groups Configuration Commands

Syntax:

```
switch group GROUPID {add | del} IFNAME[:{TAG|0}] ...
```

```
switch group GROUPID {repeater|trunk}    {on|off}
```

```
switch group GORUPID {(up|down)stream} {SCID|0}
```

```
switch group GROUPID vlan {TAG|LIST|0}
```

```
switch group GROUPID xvlan {TAG|LIST|0}
```

```
switch group GROUPID info INFO_STRING
```

```
switch group GROUPID setid NEWGROUPID
```

```
switch group GROUPID stp { off | on | dump }
```

```
switch group GROUPID stp priority [PRIO] #(default: 57344,
   step: 4096)
```

```
switch group GROUPID stp forwarddelay [DELAY] #(default: 15
   sec)
```

```
switch group GROUPID stp maxage [TIME] #(default: 20 sec)
```

```
switch group GROUPID stp port IFNAME priority [PRIO]
   #(default: 128,step 16)
```

```
switch group GROUPID stp port IFNAME cost [COST] #(default:
   200000(RSTP),65535(STP))

switch group ID igmp-snooping { off | on }

switch group ID order N

switch {group ID | interface IFNAME}

      [ setpri|addpri prio ]

      {deny | permit | showrules}

switch group GROUPID

       [dump [interface]] [WILDCARD]]

       [dbdelete   MACADDRESS]

       {start | stop | remove}

switch group GROUPID in-trunk [{GROUPID|0}]

switch admin-group {GROUPID|0}

switch group GROUPID {add | del} IFNAME[:{TAG|0}] ...
```

The command adds or deletes specified interfaces to/from the switching group.

- **GROUPID** - numeric switching group identifier (1-4095)
- **add|del** - these commands add/delete specified interfaces to/from the switching group. If "add" keyword is used and there is no switching group with GROUPID identifier, it will be automatically created.
- **IFNAME** - network interface name which should be added or deleted from the switching group.

- **TAG**. This option allows different manipulations with VLAN tags of the packet when the packet is sent through this interface. The following options are available:

  - **TAG** is specified for the interfaces and its value is >0. That means that any packet forwarded to the interface by the switch will be tagged with a VLAN tag **TAG**. If the packet already had a tag, this tag will be retagged to **TAG**.
  - **TAG** is not specified. This means that the packet stays unmodified.
  - **TAG** is specified and its value is zero. This means that the packet sent through this interface will be untagged if it was previously tagged or sent without any changes if it was not tagged.

Example:

```
switch group 3 add rf5.0:10 eth0:0
```

In this example, all packets switched by group 3 will be tagged with VLAN TAG 10 when sending through rf5.0 interface and will be untagged when sent through eth0 interface.

```
switch group GROUPID {repeater|trunk} {on|off}
```

This command turns on/off the modes for **repeater** or **trunk**.

In a **repeater** mode the group switches the packets by simple retranslation to any other interfaces other than the one the packet was received from.

In **trunk** mode, the group switches all the packets received through eth* interfaces in such a way that when packets are sent to rf* interfaces, these packets are places in a group with a number corresponding to the packet's VLAN TAG. When receiving the packet from rf* interfaces, trunk group sends these packets to eth* interface tagging them with a switch group number this packet was received from.

Example:

```
switch group 12 trunk on
```

If trunk group which will provide transmission of multiple VLAN flows in different directions is enabled on device then in-trunk option should be used on a subscriber station for exact instruction of what trunk group is the group:

```
switch group GROUPID in-trunk [{GROUPID|0}]
```

For example, if a Group No100 on a subscriber station is a member of a trunk Group No5 (Group No100 was formed as a result of conversion of VLAN ID No100

into the Group No100), subscriber station switch configuration should have the following command: **switch group 100 in-trunk 5**

This option allows creating multiple disjoined trunk groups in the same network with the same VLAN flows inside.

```
switch group GROUPID vlan {TAG|LIST|0}
```

This command defines that GROUPID group will switch the packets which are tagged with **TAG** VLAN tag or with VLAN tags specified is a LIST of **numrange** type. In order to cancel this VLAN filtration, TAG should be specified as zero.

IMPORTANT

When enabling this VLAN tag filter other rules (see below) do not work.

Example:

```
switch group 5 vlan 5
```

```
switch group GROUPID xvlan {TAG|LIST|0}
```

This command unlike the "vlan {TAG|LIST|0}" rule allows groups to handle also not tagged packets.

Examples:

```
switch list MYNET numrange add 100 200 300
```

```
switch group 10 xvlan MYNET
```

```
switch group 10 trunk on
```

Group No10 would handle packets tagged with VLAN IDs 100, 200, 300 as well as not tagged packets. Not tagged packets will be sent to MINT network with its own group number (in this case 10), tagged packets - with group numbers concurred with VLAN ID.

```
switch list MYNET numrange add 100 200 300
```

```
switch group 20 vlan MYNET
```

```
switch group 20 trunk on
```

Group No20 handles only tagged packets from the MYNET list and transmits them upgrading VLAN ID number to appropriate group (and vice versa).

```
switch list MYNET numrange add 100 200 300
```

```
switch group 30 vlan MYNET
```

```
switch group 30 trunk off
```

Group No30 handles only tagged packages from the MYNET list and transmits them without changing with the group number 30.

```
switch group GROUPID info INFO_STRING
```

This command allows to add comments to switch group description.

```
switch group GROUPID setid NEWGROUPID
```

This command changes GROUPID of the switching group to NEWGROUPID.

Example:

```
switch group 3 setid 7
switch group GROUPID
        [dump [interface] / showblack] [WILDCARD]]
        [dbdelete   MACADDRESS]
        {start | stop | remove}
```

Here:

- **dump** - prints the database of all known MAC-addresses
- **interface** - prints the database of all known MAC-addresses by grouping them according to interfaces
- **showblack** - prints the black list of unknown MAC-addresses
- **WILDCARD** - the output will be filtered according to the WILDCARD criteria.
- **dbdelete MACADDRESS** - deletes all records from MAC-address database connected with a specified MACADDRESS
- **start|stop** - starts/stops a specified switching group.
- **restart** - restarts the switching group (same as "switch group GROUPID start; switch group GROUPID start" set of commands). The command is used to clean the switching group database.
- **remove** - deletes a specified switching group from the switch configuration.

Examples:

```
switch group 3 dump eth0
```

```
switch group 5 start
```

In order to access the switches which are connected wirelessly from eth* interfaces (e.g. workstations which are connected using wired interfaces to one of the units) on such units (border units of the wireless network) one of the groups should be selected as **admin group**. All packets destined for any of the switches in wireless network will be sent by this group.

```
switch admin-group {GROUPID|0}
```

MAC Switch supports **STP protocol**, namely two its versions: STP and RSTP. To implement this feature the following switch commands are introduced:

```
switch group GROUPID stp { off | on | dump }
```

This command with off/on options enables or disables STP for the group. Dump option allows to see STP state of the group.

"switch group GROUPID stp dump" command output:

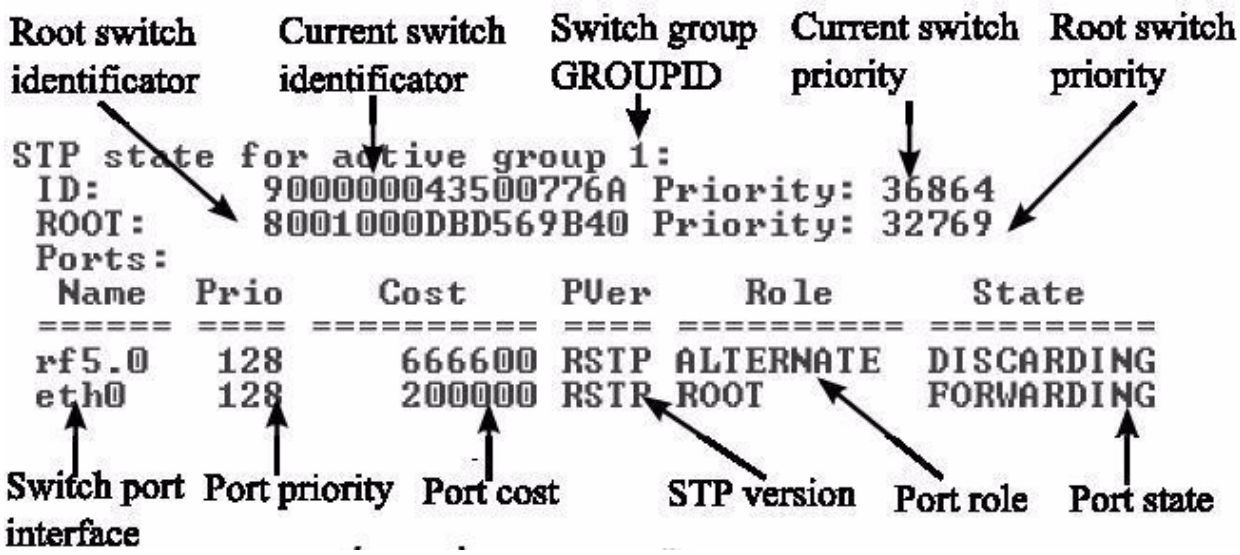


Figure 3-14: Switch Group STP Output

```
switch group GROUPID stp priority [PRIO]
```

This command sets STP priority of a switch, where [PRIO] - priority value. If priority is not specified then default value 57344 is set. When setting priority value one should take into consideration that it will be automatically rounded down to a value divisible by 4096 (step 4096).

```
switch group GROUPID stp forwarddelay [DELAY]
```

This command sets STP parameter "forward delay" which determines a time that switch spend in "listening" and "learning" states, where [DELAY] - time value in seconds. If not specified default value is set that is equal to 15 seconds.

```
switch group GROUPID stp maxage [TIME]
```

This command sets STP parameter "MAX age" which determines time for switch to deliver BPDU-packet, where [TIME] - value of this parameter in seconds. If not specified default value is set that is equal to 20 seconds.

```
switch group GROUPID stp port IFNAME priority [PRIO]
```

This command sets STP switch, where IFNAME - port interface name, [PRIO] - port priority value. If not specified default value is set that is equal to 128. When setting priority value one should take into consideration that it will be automatically rounded down to a value divisible by 16 (step 16).

```
switch group GROUPID stp port IFNAME cost [COST]
```

This command sets STP parameter "cost" of a switch port which determines switch port cost, where [COST] - value oh this parameter. If not specified default value is set that is equal to 200000 for RSTP, 65535 for STP.

Example:

```
switch group 1 add eth0 rf5.0
switch group 1 stp priority 36864
switch group 1 stp on
switch group 1 start
```

In this example switch group "group 1" is configured. STP protocol support is enabled and STP switch priority is set to 36864 for this group.

```
switch group ID igmp-snooping { off | on }
```

This command disables/enables "IGMP snooping" function for the switching group.

Example:

```
switch group 1 igmp-snooping on
switch group ID order N
```

The logic of assigning switch groups to packets is the following:

- Groups are run over in the order of their appearance in a configuration.

- The first group that is suitable for a packet is chosen and the process is stopped.

The command sets the order in which the concrete group will be run over during the assigning process.

```
switch {group ID | interface IFNAME}
    [ setpri|addpri prio ]
    {deny | permit | showrules}
```

This command allows setting/increasing the priority of packets passing through the group. "**Setpri**" parameter is used to change a priority to the value specified in the command. When using "-1" value a package priority is dropped to the lowest priority. "**Addpri**" is used to change a priority only in case it is higher than the previous one (Note: the smaller is the value the higher is the priority). So you can only increase priority using "**addpri**" parameter.

Example:

```
switch group 1 addpri 15
```

3.7.4 Rules Configuration Commands

Rules are used for the following purposes:

- Selecting an appropriate switching group when packet is received through eth* interface. Packet will be switched only by that group to which rules it fully satisfies.

- When packet is chosen by the switching group and group decides whether this packet needs to be sent through one of the interfaces. The packet will only be sent if it satisfies the rules of this interface.

The rules consist of rules list and a decision by default (deny/permit). Each rule consists of a sequential number, condition and decision (deny/permit). While going through the list, the switch checks whether a packet matches the rule. If it matches the rule, the decision set for this rule is applied to the packet. Otherwise, the list of rules is viewed further. Rules are taken according to their sequential number in ascending manner. If a packet does not match to any rule, the default decision for this group or interface is taken.

The condition might consist of one or several parameters which are checked with the packet. Five packet parameters can be checked:

1 Source interface (iface)

2 Source MAC-address (src)

3 Destination MAC-address (dst)

4 VLAN tag (vlan)

5 Ethernet-level protocol number (proto)

For each parameter a corresponding **list** of values should be specified. Moreover, in the condition a PCAP expression may be present. This expression will be considered as a "pseudo parameter" of the packet and is called **match**. Therefore, the packet is considered to have matched the condition, if all its parameters match to the corresponding acceptable values from the lists and/or the packet satisfies to the expression of **match** type. One or more parameters might be missing in a condition clause - in this case it will mean that packet satisfies to that part of the condition which is missing. If the list of acceptable values is empty, non of the values of the corresponding parameter can match the condition even if this parameter is missing in the packet (for example, VLAN tag).

Rules configuration is implemented using the following command:

```
switch {group GROUPID | interface IFNAME} rule NUMBER
       [set NEWNUMBER]
       [src   LIST] [dst   LIST] [vlan LIST]
       [iface LIST] [proto LIST] [match LIST]
       [ setpri|addpri prio ]
       [ deny | permit ]   [ remove ]
```

Here:

- *GROUPID* and *IFNAME* - number of the group or interface.
- *NUMBER* - sequential rule number
- *set NEWNUMBER* - changes the number of the rule to NEWNUMBER
- *remove* - deletes the rule
- *deny* | *permit* - sets the decision for the corresponding rule
- *src, dst, vlan, iface, proto, match* - commands for specifying the **lists** of acceptable values for the corresponding parameter of the packet.

- *setpri|addpri prio* - command allows setting/increasing the priority of packets passing through the group. "**Setpri**" parameter is used to change a priority to the value specified in the command. When using "-1" value a package priority is dropped to the lowest priority. "**Addpri**" is used to change a priority only in case it is higher than the previous one (Note: the smaller is the value the higher is the priority). So you can only increase priority using "**addpri**" parameter.

Example:

```
switch list MACGROUP1 MACGROUP1 mac add 00:01:02:03:04:05
   00:11:12:13:14:15

switch list VGROUP numrange add 10 20-30 40

switch list IP_NET3845 match add 'arp net 195.38.45.64/26 ||
   ip net 195.38.45.64/26'

switch group 5 rule 10  src MACGROUP1 vlan VGROUP match
   IP_NET3845 deny

switch group 5 rule 20   dst MACGROUP1 vlan VGROUP match
   IP_NET3845 deny

switch group 5 permit

switch group 1 rule 1 setpri 10
```

In order to configure a default decision for group/interface the following command should be used:

```
switch {group GROUPID | interface IFNAME}

       {deny | permit }
```

3.7.5 Control Commands

Syntax:

```
switch keeptag [(on|off)]

switch resynchronize

switch trace { off | on | verbose }

switch stptrace { off | on }

switch {dump [WILDCARD]|MACADDRESS}

switch local-tag TAG
```

```
switch igmp-snooping dump [detail]

switch igmp-snooping lmqt Value

switch igmp-snooping gmi Value

switch igmp-snooping static-add MCAST IF_NAME [MAC]

switch igmp-snooping static-del MCAST IF_NAME [MAC]

switch igmp-snooping querier group N [source X] [mcast X]
   [vlan N] {start|stop}


switch {start | stop | restart | dead-interval DEAD_INTERVAL}


switch resynchronize
```

Forces to reload lists which had an external file as a source

```
switch trace { off | on | verbose }
```

Enables/disables logging of service information into a system log. **Verbose** option provides more detailed information to be written in the system log.

```
switch stptrace { off | on | verbose }
```

Enables/disables logging of STP service information into a system log. **Verbose** option provides more detailed information to be written in the system log.

Switch MAC-address database is a routing table of MAC-layer which contains information on how the packet should be delivered to its destination (dst). Each switching group has an independent database. Records in the database are formed automatically based on the source address of the packet which was received by one of the interfaces included into a switching group.

Moreover, the database always contains records corresponding with interfaces included into the switching group. These records are called local records. Each record has its life span. If, during this life span, none of the interfaces have received a packet with a source address from this record, this record is deleted from the database. By default, life span is five minutes. To change this parameter, the following command can be used:

```
switch dead-interval <DEAD_INTERVAL_IN_SECONDS>
```

To start/stop/restart the switch, the following command can be used:

```
switch {start | stop | restart}
```

If one of the switching groups is in **trunk** mode, in order to transfer local packets through this group into wired interface (eth*) one can specify the value of the VLAN tag with which these packets should be tagged:

```
switch local-tag TAG
```

After being transferred into wired interface (eth*) local packets are untagged back.

```
switch keeptag [(on|off)]
```

This command allows keeping local packets tagged with specified VLAN TAG (by using "switch local-tag TAG" command) after they were transferred into wired interface (eth*).

```
switch igmp-snooping dump [detail]
```

This command allows to see a list of IGMP hosts which are subscribed on Internet Protocol multicast group.

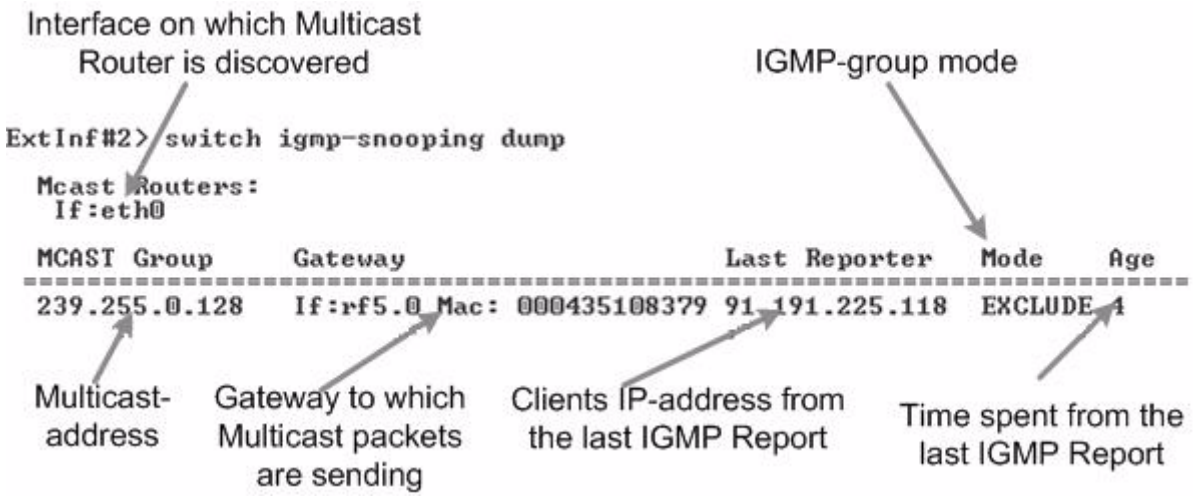


Figure 3-15: Switch IGMP Snooping Dump Output

Parameter "**detail**" allows seeing detailed information on Multicast-subscribers.

```
switch igmp-snooping lmqt Value
```

This command sets "Last Member Query Time" value, i.e. the maximum time during which the switch will wait for the answer from active subscribers after receiving "IGMP leave". If no answer is received the switch will stop Multicast packets delivery to the particular Gateway. Gateway is an Ethernet interface or radio interface with a MAC-address of the device on the other side of the link.

```
switch igmp-snooping gmi Value
```

This command sets "Group Membership Interval" value, i.e. the amount of time that must pass before a Multicast Device decides there are no more clients subscribed to a Multicast group (no more "IGMP report" messages in the group).

```
switch igmp-snooping static-add MCAST IF_NAME [MAC]
```

This command creates static subscription on a Multicast-address.

```
switch igmp-snooping static-del MCAST IF_NAME [MAC]
```

This command removes static subscription on a Multicast-address.

```
switch igmp-snooping querier group N [source X] [mcast X]
   [vlan N] {start|stop}
```

This command starts/stops (**start/stop**) "Querier" function operation. "IGMP Querier" substitutes the functions of Multicast Device when organizing video systems using "IGMP Snooping" services.

IGMP Querier parameters:

- **group N** - defines a switching group that uses "IGMP Snooping" services.
- **source X** - sets source IP-address for Multicast packets
- **mcast X** - sets concrete Multicast Group to be allowed for subscription.
- **vlan N** - enables transmission of Multicast packets using Vlan.

3.7.6 Sample configuration

```
switch list VGROUP numrange add 10 20-30 40
switch list ALL_VLAN numrange add 0-4095

switch group 5 add eth0 rf5.0
switch group 5 rule 10 vlan VGROUP permit
switch group 5 deny
switch group 5 start

switch group 15 add eth0 rf5.0
switch group 15 rule 10 vlan VGROUP deny
switch group 15 rule 11 vlan ALL_VLAN permit
```

```
switch group 15 deny
switch group 15 start

switch group 25 add eth0 rf5.0
switch group 25 rule 10 vlan ALL_VLAN deny
switch group 25 permit
switch group 25 start
switch admin-group 25

switch start
```

Here three switching groups are created. Group 5 switches the packets with VLAN tags 10, 20-30 and 40. Group 15 switches the packets with any VLAN tag with exception for those switched by group 5. Group 25 is switching all the packets without VLAN tags. Moreover, group 25 will be used to send the traffic to "outer" world.

3.8 Dfs (Dynamic Frequency Selection)

This command is used to configure DFS (Dynamic Frequency Selection) function of a radio interface.

Syntax:

```
dfs "interface_name" freq { all |"frequency_list"}
dfs "interface_name" cot hh:mm
dfs "interface_name" scansec <seconds>
```

Description:

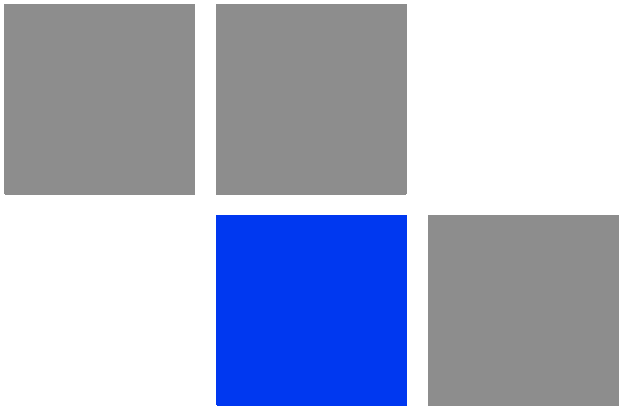
- **dfs "interface_name" freq { all |"frequency_list"}** - sets list of frequencies ("*frequency_list*" parameter) that are allowed for choosing by DFS or allows DFS to use all radio interface enabled frequencies ("*all*" parameter).

- **dfs "interface_name" cot hh:mm** - sets the exact time in hours and minutes when frequency channel scanning will be performed.

- **dfs "interface_name" scansec <seconds>** - sets scanning time in seconds

DFS default operational characteristics:

- Channel occupation time: 24 hours
- Scanned time: 6 seconds for each available frequency
- Listening to the Radar on the chosen frequency: 1 minute



Chapter 4

Layer 3 Command Set - IP Networking

In This Chapter:

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- "Netstat Command (Network Statistics)" on page 167
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- "Snmpd Command (SNMP Daemon)" on page 190
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- "DHCP Client. dhcpc Command" on page 229
- "DNS Client" on page 231
- "Nslookup" on page 232

4.1 Ifconfig Command (Interfaces Configuration)

The command is used to set and view configuration of network interfaces.

Syntax:

```
ifconfig IFNAME
[address[/netmask] [ [delete | -alias] [ up ] [ down ]
[media MediaType]]
[vlan TAG  [-]vlandev IFParent]
ifconfig -a
```

Description:

This command allows setting and viewing the configuration of interfaces specified by their ID numbers.

The command has the following parameters and flags:

- **IFNAME:** specifies the name of an interface (to see all interface names, an **ifconfig -a** or **netstat -i** command may be executed).
- **address:** specifies the IP-address assigned to the interface. May be specified as:
  - » address/number of bits in the mask
  - » address:mask
  - » address proper

Example:

```
ifconfig eth0 inet 192.168.1.1/26
ifconfig eth0 inet 192.168.1.1:255.255.255.192
ifconfig eth0 inet 192.168.1.1
```

up|down: flags enabling/disabling the interface.

System limitations:

lo0 interface cannot be set to **down** state. Radio interfaces states are not saved in the configuration (after rebooting all interfaces are in the **up** state)

Example:

```
ifconfig eth0 up

ifconfig eth0 1.1.1.1/24 up

ifconfig rf5.0 down
```

Media parameter allows specifying physical interface eth0 10/100 properties.

Allowed values:

100BaseTX-fullduplex, 100BaseTX-halfduplex, 10BaseT-fullduplex, 10BaseT-halfduplex, auto

By default: **auto**

For **vlanX** (VLAN IEEE 802.1q) configuration one should use **vlan** and **vlandev** options in **ifconfig** command.

Vlan parameter sets VLAN tag for the current interface (1-4094). **Vlandev** parameter creates a connection with a physical interface which serves the media - eth0 in this case.

Example:

```
ifconfig vlan1 1.1.1.1/24 vlan 5 vlandev eth0 up
```

or

```
ifconfig vlan1 1.1.1.1/24 up

ifconfig vlan1 vlan 5 vlandev eth0

ifconfig -vlandev eth0
```

(last line in the example cancels the connection between vlan1 logical interface and physical device **eth0**)

Both additional parameters of **vlanX** interface should be entered in one line as it is shown in the example, and if needed one can add a new IP-address setup. For the normal vlanX interface functioning, a physical interface eth0 should be in the active state (**up** flag).

delete | -alias: alias flag indicates that several IP-addresses are assigned to one interface. Each new IP-address assigned to an interface (except the first, called primary) is considered an alias address and shall have the alias option set.

For example, after executing the commands:

```
ifconfig eth0 inet 193.124.189.1/27 up
ifconfig eth0 inet 10.0.0.1 alias
```

there will be two addresses from two different networks assigned to the same **eth0** interface.

To remove any address from an interface, an ifconfig command is executed with the **delete** or **-alias** option following the address to be removed.

Example:

```
ifconfig eth0 inet 193.124.189.1/27 -alias
```

The **[-]alias** option may be put in any **ifconfig** command, that is, all addresses assigned to an interface are considered as equivalent aliases. If the first (primary) address is removed, the next (in the order of their assignments) becomes primary.

To display the current configuration of an interface, an **ifconfig** command may be executed with the interface name as the only parameter.

To see the configuration of all interfaces of the device, use the **ifconfig -a** command.

4.2 Tun Command (Tunnels Building)

The command specifies the parameters of a software tunnel.

General Description:

Tunnels are used to merge two remote and physically not connected networks into one logical structure. Tunnels are widely used to create corporate networks or the so-called virtual private networks (VPN): several remote offices, connected to the network through the same or different providers, are connected to the company headquarters or to each other by tunnels, thus forming one corporate structure. Common IP address space and registration/accounting policy can be used throughout the whole VPN-based corporate network, independently of network provider(s) used.

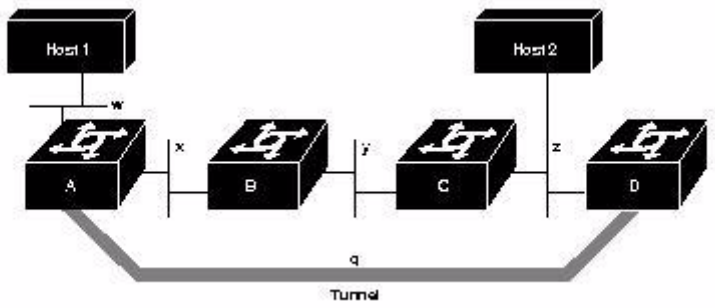

Figure 4-1: Tunnels Between Physically Separated Networks

Tunnels also solve the problem of using common transport media in a public network so that different clients could be provided with services by several providers. It means that a client can be connected by a tunnel to a specific provider, to be serviced by that provider, irrespective of the client's connection point to a common transport network.

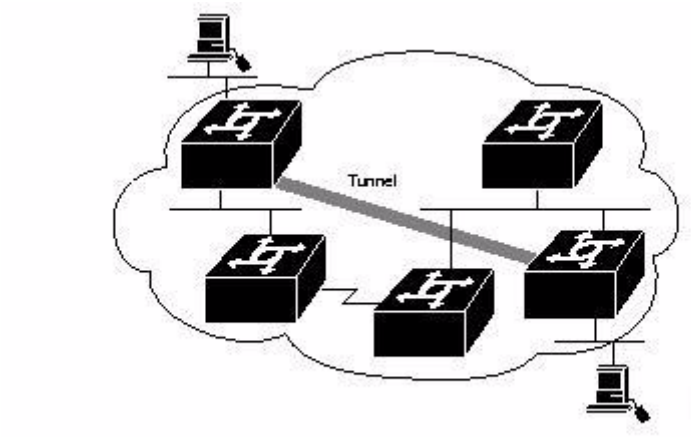

Figure 4-2: Tunnels Inside the Same Network

There are several approaches to build tunnels. One of these, IP into IP Encapsulation (described in RFC 2003), is implemented in OS WANFleX. This technology is used, for example, in Cisco Systems routers, and is a subset of the IPSEC protocol supported by several operating systems.

Within this approach, tunnels are implemented as point-to-point (P2P) links between two endpoint devices. The whole data stream through such a link is encapsulated into IP packets at one end of a link and is delivered to its opposite end through the existing transport network.

Four parameters are necessary to configure a tunnel:

1 The internal IP-address of the local end of the P2P link.

2 The internal IP-address of the remote end of the P2P link.

3 Real source IP-address to be specified in the outgoing packets.

4 Real destination IP-address to be specified in the outgoing packets.

Internal IP-addresses of both ends of a P2P link are set using ifconfig command; all other parameters are specified by the tun command (see example below).

Syntax:

```
tun N src IP-addr dst IP-addr [mtu M] [clear].
```

Description:

Assigns the source (**src**) and destination (**dst**) real IP-addresses to a tunnel specified by its logical number **N** which has been created by an **ifconfig** command.

Outgoing packets are encapsulated into IP datagrams and sent to the **dst** address. The **src** address is inserted into the datagram as source address.

CAUTION

The **dst** address shall also be attainable through an interface of the device different from that used to access the tunnel. This can be done, for example, by using explicit static routing (the route add command), or by prohibiting importation of some of the RIP protocol route descriptors arriving to that interface. If this condition is not satisfied, a looping may happen, when already encapsulated packets come back to the tunnel entrance, and so on, causing system overload. The system watches over such situations, and when discovering a loop, drops erroneous packets and writes a message **tunX**: **looping** … into the system log.

The **src** address must be a real IP-address for one of the devices' interfaces; for the same reason, it shall be attainable from the device at the tunnel's remote end through the existing network (and not only through this tunnel).

On the remote site of the tunnel, the **src** and **dst** addresses swap their roles.

The **mtu** optional parameter allows the user to set the Maximum Transfer Unit size for packets going through the tunnel. Default value is 1480 bytes.

Disabling the tunnel number **N** may be done by executing the command:

```
tun N clear
```

Example:

```
ifconfig tun0 1.1.1.1 1.1.1.2
tun 0 src 195.23.23.23 dst 194.34.34.34
```

Here, the **ifconfig** command defines internal IP-addresses for both ends of a **tunnel #0** as addresses for an interface denoted as **tun0**; then, the tun command defines real IP-addresses for the **tunnel #0** extremities.

At the opposite side of the tunnel this would look as follows:

```
ifconfig tun0 1.1.1.2 1.1.1.1
tun 0 src 194.34.34.34 dst 195.23.23.23
```

If you use a Cisco Systems router at the remote end, you may configure it as follows:

```
interface Tunnel0
   ip address 1.1.1.2 255.255.255.252
   tunnel source 194.34.34.34
   tunnel destination 195.23.23.23
```

```
   tunnel mode ipip
!
```

4.3 Qm Command (QoS Configuration)

The command manages the "Quality-of-Service" (QoS) parameters

General description:

QoS manager is a convenient and flexible mechanism to manipulate data streams going through the device. The user can create up to 200 logical channels characterized by different properties (such as priority levels and data transfer rates), and then assign data streams to these logical channels according to special rules of assignment. Packets going through different channels are thus modifying their own properties as well as properties of their respective data flows.

With further development of our system, new properties would be added to the list of different properties characterizing a channel.

Syntax:

```
qm option {[-]voice [-]dot1p [-]tos [-]icmp [no]strict}

qm classN {if=IFNAME [max=N] [ceil=N] [ceilprio=N]
   [parent=N]} | {clear}

qm chN [max=N] [ceil=N|0] [ceilprio=N|0] [latency=N|0]
   [pri=N] [[no]strict]]  [pps=T] [to=ADDR] [vlan=N|-1|-2]
   [dscp=N|-1|-2] [dot1p=N|-1|-2] [classN] | clear

qm stat [clear]

qm add [ifname] chN [pass] rule...

qm del R

qm mov R S
```

where

- N,L,X,P,R,S,T are integers;
- addr is an IP-address;
- rule is a packet filtering rule with the same syntax as in the ipfw command.

CAUTION

Parameter values shall be put after their keywords (if any) without blanks, as shown above; no blank may be put before or after "=" sign.

Description:

```
qm classL if=ifname | max=N
```

This command creates a service class **#L** assigning it to an interface specified by ifname. It is used for dynamic bandwidth allocation between different channels on the same interface. If the option "**max = N**" is used the total bandwidth of the class will be limited to a given value (thousands bps), otherwise for the total bandwidth limiting the present interface physical speed will be used.

To disable this parameter type:

```
qm classL if = ifname max = 0
```

You can create a hierarchy of service classes where a "parent" class is used for the dynamic allocation of its bandwidth between its subsidiary classes. To do this **[ceil=N] [ceilprio=N] [parent=N]** parameters are used. The use of **[ceil=N] [ceilprio=N]** parameters is the same as in **qm chN** command. **[parent=N]** parameter defines "parent" class for the current class, where **N** - is a value of a "parent" class.

```
qm chN [max=X] [ceil=N|0] [ceilprio=N|0] [latency=N|0]
   [pri=P] [[no]strict]]  [to=addr] [vlan=N|-1|-2]
   [dscp=N|-1|-2] [dot1p=N|-1|-2] [classL] / clear
```

This command defines a logical channel #N (N=1...200) with properties specified by one or more command options as follows:

- **max=X** sets maximum data rate for the channel in Kbit/s. Value range: from 10 to 10000. If set to 0, cancels any speed limitation for the channel.

- **classL** assigns service class #L to the channel. This additional parameter relates to the above defined data rate limitation, making it flexible: when the total bandwidth of the interface having this service class is not fully used, the extra bandwidth may be granted to such channel, thus exceeding its predefined data rate limit, up to full load of the interface. When, however, there are several such channels competing for extra bandwidth, it is divided between them proportionally to their respective predefined speed limits. (See examples below)

- **ceil=N** determines how much of interface bandwidth of class N can be used by the channel when bandwidth of class L is not used entirely. Measured in kilobits per second. To disable the parameter set its value to 0.

- **ceilprio=N** sets priority for the channel that is used when interface bandwidth can be used by several channels. There are 17 priorities from 0 (the highest) to

16 (the lowest). Default value is 0 therefore when setting another value it is possible only to lower the priority.

- **latency=N** determines the maximum time for the packets to stay in the channel. If a packet is waiting in a queue of the channel more than this time then it is discarded. Measured in milliseconds. To disable set the parameter to 0.

- **pri=P** Sets priority level of the specified channel (0..16). Smaller values correspond to greater priority levels.

- **[no]strict** Sets a QM policy that will be applied to current channel. "Strict Priority" policy is when packets from queue with lower priority are not processed before queue with higher priority is not empty. "Weighted Fair Queuing" policy (by default) is when even if higher priority queue is not empty packets from other queues will be processed in a distinct sequence relative to a higher priority queue.

- **pps=T** Sets the limit for the packets per second for the specified channel

- **to=addr** redirects the whole stream to the specified IP-address irrespectively of the present routing conditions. The specified address shall be directly attainable through one of the device interfaces (without additional routing). This may be useful when the device serves as a network access unit, and two or more different clients want to access different providers through one unit.

- **vlan=N, dot1p=N, dscp=N** manipulates DSCP and/or 802.1p labels. Value "-2" deletes parameter from command line, value "-1" disables the field:

  - DSCP (valid values are 0-63) sets to 0 (zero).

  - 802.1p priority (valid values are 0-7) sets to 0 (zero) and, if VLAN ID isn't introduced, is deleted with VLAN header.

  - VLAN ID (valid values are 0-4095) is deleted with VLAN header regardless of 802.1p priority.

If several of the above parameters are specified in the same command then speed limitation is applied first then redirection and only then priority. If **vlan** and **dot1p** parameters are specified in the same command then **vlan** is processed first.

```
qm chN clear
```

Cancels the **N**-th logical channel current specification, making its number free for another specification.

```
qm add [ifname] chN [pass] rule ...
```

Specifies one or more rules for accepting packets at the channel **#N**. Rules are specified using the same syntax as in the **ipfw** command.

Optional **ifname** parameter specifies the device's interface through which a packet shall arrive for being accepted at the specified channel.

All rules specified on a device constitute a numbered list; a rule is added at the end of this common list at the moment when it is specified for some channel, and then may be moved to another position (see below). To display the list of all rules with their numbers, use the config show command.

Each packet arriving to the device is checked against the set of rules in the order of their enumeration, until a rule is found which the packet satisfies, or until the end of the list of rules is encountered. Once such a rule is found, the packet is directed to the channel corresponding to the rule, without checking it against the remaining rules in the list (if not using **pass** parameter). Therefore, the order of rules is very important for correct dispatching of packets among channels.

Optional "**pass**" parameter allows a packet to pass a rule executing the related actions of this rule and continue with other rules in the list.

qm stat command displays statistics of the specific channel (only for channels with speed limitation).

```
qm del R
```

This command deletes the R-th rule from the list.

```
qm mov R S
```

Moves the **R**-th rule to the **S**-th position.

Transparent packets prioritization is supported in MINT network. It is performed by using channels management in "qm" command. Administrator can put streams into different channels based on "qm/ipfw" rules as well as "tos" and "dscp" fields.

```
qm ch1 pri=12

qm add ch1 all from x/x to y/y

qm add ch1 dscp31 all from a to b

qm add ch1 dscp42
```

Each channel can be assigned a priority (0..16). Once assigned, a priority will be automatically recognized by every node inside MINT network. Priority scheme looks as follows:

QM_PRIO_NETCRIT	0
QM_PRIO_VOICE	1
QM_PRIO_RT1	2
QM_PRIO_VIDEO	3
QM_PRIO_RT2	4
QM_PRIO_QOS1	5
QM_PRIO_QOS2	6
QM_PRIO_QOS3	7
QM_PRIO_QOS4	8
QM_PRIO_BUSINESS1	9
QM_PRIO_BUSINESS2	10
QM_PRIO_BUSINESS3	11
QM_PRIO_BUSINESS4	12
QM_PRIO_BUSINESS5	13
QM_PRIO_BUSINESS6	14
QM_PRIO_BUSINESS7	15
QM_PRIO_BUSINESS8	16

Priorities "1" and "2" are additionally processed as "voice". Packets from which the priority is not clearly defined will be sent via common queue with "Best Effort".

The "**qm option**" allows automatic prioritization management of data flows in the device. Command options **[-]voice [-]dot1p [-]tos [-]icmp** enable/disable

automatic prioritization of voice packets, packet labeled with IEEE 802.1p priority (below is a compliance scheme of MINT and IEEE 802.1p priorities), packets labeled with TOS, packets labeled with ICMP. The **[no]strict** option means that "Strict Priority" policy is applied to all queues, otherwise (by default) "Weighted Fair Queuing" policy is used. "Strict Priority" policy is when packets from queue with lower priority are not processed before queue with higher priority is not empty. "Weighted Fair Queuing" policy is when even if higher priority queue is not empty packets from other queues will be processed in a distinct sequence relative to a higher priority queue. For example, 4 package from queue with priority 1 - 1 package from the queue with priority 2, 8 packages from queue priority 1 - 1 package from the queue with priority 3.

Table 4-1: Compliance Scheme of MINT and IEEE 802.1p Priorities

MINT	IEEE 802.1p
QM_PRIO_BUSINESS8	0 BE Best Effort
no priority	1 BK Background
no priority	2 Spare
QM_PRIO_BUSINESS1	3 EE Excellent Effort
QM_PRIO_QOS3	4 CL Controlled Load
QM_PRIO_VIDEO	5 VI Video
QM_PRIO_VOICE	6 VO Voice
QM_PRIO_NETCRIT	7 NC Network Control

For example, the unit is configured automatically prioritize packets labeled with IEEE 802.1p priority. The node receives a package labeled with IEEE 802.1p priority, "6 VO Voice". The node will assign him "QM_PRIO_VOICE" priority and in accordance with the priorities scheme, this package will be processed before packets with other priorities.

Attention: Real prioritization within MINT network is conducted by priority, given by the option **pri=N**.

DSCP label is transparently transmitted through MINT in any of its modes.

802.1p priority is transparently transmitted only in switch MINT mode.

If necessary, when leaving MINT network **dot1p** *and* **dscp** *parameters can be assigned by the operator.*

QoS Manager allows enough flexibility for prioritizing and remapping traffic (see examples below).

Examples:

```
qm ch1 max=64
qm add eth0 ch1 all from 0/0 to 0/0
```

When used on a client unit, sets the data rate for outgoing traffic at 64 Kbit/s limit.

```
qm ch1 pri=5 qm add ch1 all from 1.1.1.0/24 to 0/0
qm add ch1 all from 0/0 to 1.1.1.0/24
```

Establishes for the traffic from or to 1.1.1.0/24 network the highest priority over all other data flows.

```
qm ch1 pri=5
qm ch2 pri=10
qm add ch2 all from 1.1.1.0/24 to 0/0
qm add ch2 all from 0/0 to 1.1.1.0/24
qm add ch1 all from 0.0 to 0/0
```

The 1.1.1.0/24 network traffic will have the lowest priority as compared to other data flows. *Please note the order of rules in the above list. The last rule, which is satisfied by any packet, may only be at the end of the list.*

```
qm ch1 to=10.10.10.10
qm ch2 to=20.20.20.20
qm add ch1 all from 1.1.1.0/24 to 0/0
qm add ch2 all from 2.2.2.0/24 to 0/0
```

Subscribers of the 1.1.1.0/24 network will be serviced by the 10.10.10.10 provider, while the 2.2.2.0/24 subscribers will use the 20.20.20.20 provider.

In more complicated situations, when the devices of service providers are not directly accessible from the given node, one would better start with defining tunnels to those providers, and then redirect traffic to those tunnels.

```
qm option -voice tos
```

This command disables voice automatic prioritization and enables tos automatic prioritization.

Example of traffic prioritization and remapping:

Channel 1 disables DSCP labels and 802.1p priorities

```
qm ch1 dscp=0 dot1p=-1
```

Channel 2 sets flow priority QM_PRIO_BUSINESS1 and DSCP label 31

```
qm ch2 pri=9 dscp=31
```

Channel 3 sets flow priority QM_PRIO_VIDEO and DSCP label 11

```
qm ch2 pri=3 dscp=11
```

Channel 4 sets flow priority QM_PRIO_BUSINESS8 and DSCP label 51

```
qm ch4 pri=16 dscp=51
```

All the traffic is coming through channel 1 for setting all priorities to null

```
qm add ch1 pass all from 0/0 to 0/0
```

Some traffic is setting into channel 2

```
qm add ch2 tcp from X.X.X.0/24 to 0/0
```

Another part of traffic is setting into channel 3

```
qm add ch3 udp from X.X.X.0/24 PORT to 0/0
```

Other traffic will be processed as non-priority traffic or can be appointed with some priority by setting into channel 4

```
qm add ch4 all from 0/0 to 0/0
```

Channel 25 sets 802.1p packet priority. If there is no VLAN heading it will be added automatically.

```
qm ch25 dot1p=5
```

Channel 26 sets 802.1p priority and VLAN ID. If there is no VLAN heading it will be added automatically.

```
qm ch26 vlan=7 dot1p=4
```

Packets which are coming from MINT network through eth0 interface and having DSCP label 11 is put into channel 25.

```
qm addout eth0 ch25 dscp11 from 0/0 to 0/0
```

Packets which are coming from MINT network through eth0 interface and having DSCP label 13 is put into channel 26.

```
qm addout eth0 ch26 dscp13 from 0/0 to 0/0
```

Example of using a hierarchy of service classes:

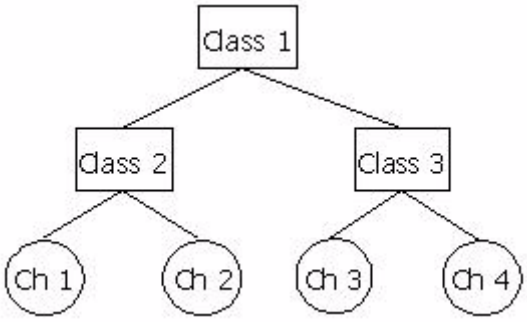

Figure 4-3: Qm

```
qm class1 max=1000

qm class2 max=600 ceil=1000

qm class3 max=300 ceil=1000 ceilprio=1

qm ch1 max=200 ceil=1000 class2

qm ch2 max=400 ceil=1000 class2

qm ch3 max=100 ceil=300 class3

qm ch4 max=200 ceil=300 class3
```

The result of these commands are a hierarchy of service classes (see figure) where channels (Ch1 and Ch2), members of the Class2, have a higher priority to use a bandwidth of 1000 kbps then channels (Ch3 and Ch4), since Class2 is of higher priority than Class3.

4.4 Route Command (Static Routes Configuration)

The command is used to configure static routing tables.

Syntax:

```
route cmd args

  cmd: add, delete.

  args: network[/mask] gateway [metric N] [-iface]
```

Description:

This command provides with manual management of system routing tables. In the normal mode, when a routing daemon is active, this command is not needed. However, in some cases it allows to achieve more precise, non-standard configuration.

Parameters:

- **add**: adds a route to a table
- **delete**: deletes a route from a table
- **network[/mask]**: destination network IP-address or host address. The parameter can be specified in the following formats: network-address/mask length, or network-address:mask, or network-address.
- **gateway**: IP-address of the device through which the address is attainable.
- **metric** - sets route metric
- **-iface** - sets interface for the given route

It is possible to use the keyword **default** instead of explicitly specifying the 0/0 IP-address.

Examples:

```
route add default 195.38.44.129

route add 193.124.189.0/27 195.38.44.108

route add 193.124.189.0:255.255.255.224 195.38.44.108
```

All routes that are described using route add command are "pseudostatic". It means that this information will be immediately placed into the configuration and will be active until it is deleted using route delete command. However, actually described routes will be put into the system tables only when there is an interface with an address and a mask within the boundaries of the gateway address set. When this address is absent routes set will be automatically deleted from system tables but still will be present in the configuration.

4.5 ARIP

4.5.1 Getting Started

ARIP module is a realization of a standard routing protocol RIP.

ARIP routing module support two RIP (Routing Information Protocol) versions - **RIP-1** and **RIP-2**.

Module configuration is performed by **arip** command.

4.5.2 Command language. Basic Principles

ARIP has its own command shell (CS). To enter the shell, execute the following command:

```
#1> arip
RIP>
```

Commands entered in CS are not case-sensitive and can be shortened until ambiguity appears. To get a quick hint you can press "?" at any time:

```
RIP>?
  configure  Configuration from vty interface
  debug      Set debugging print level
  end        End current mode and change to root mode
   (CTRL+C).
  exit       Back to WANFleX command shell (CTRL+D).
  help       Print command list
  no         Negate a command or set its defaults
  show       Show running system information
RIP>
```

CS can work in different modes. Current mode is displayed along with command prefix as "RIP(mode)#". For example, if configure **command** is entered, CS switches to config mode:

```
RIP> configure
RIP(config)#
```

The following figure shows the transition scheme between different modes of CS.

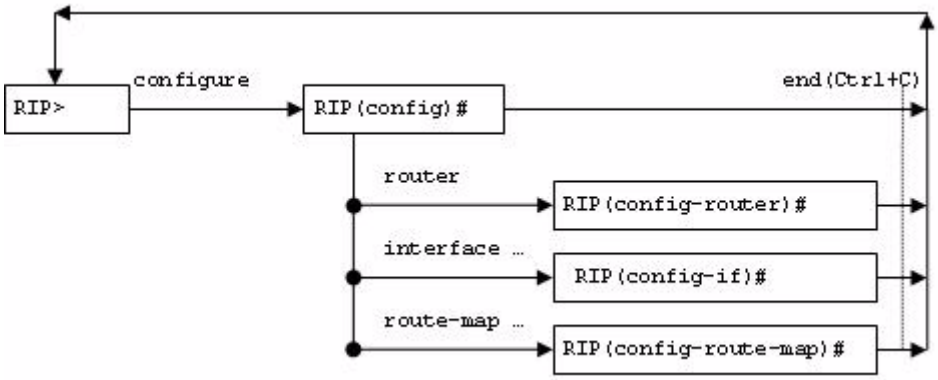

Figure 4-4: ARIP Transition

One can set the necessary mode or execute commands without specially entering into arip module. For example, if we consistently execute the following commands:

```
#1> arip configure
#1> arip router
#1> arip
RIP(config-router)#
```

while entering arip we will enter directly into necessary mode config-router (as it is shown in the example).

Every mode has its own set of commands. The following commands are available in any mode:

- **Help** - prints the list of commands for the current mode
- **No** - Negate a command or set its defaults
- **End** - goes back from the current mode to the base mode
- **Exit** - exit to WANFleX CLI from RIP CS

Debug level command sets debugging level from 0 to 255.

At the start, CS is in the base mode which has a set of commands to view current router state. In order to switch to the configuration mode you should have superuser rights. After entering a configuration mode, the configuration is being blocked and entering in this mode from other terminal (e.g. other telnet session) is prohibited. In order to avoid a "dead" block of the session, CS automatically quits the configuration mode after five minutes of no activity.

Context help is always available using "?". For example:

```
RIP> config
RIP(config)#?
  access-list  Add an access list entry
  clear        Reset functions
  end          End current mode and change to root mode
   (CTRL+C).
  exit         Back to WANFleX command shell (CTRL+D).
  help         Print command list
  interface    Select an interface to configure
  key          Authentication key management
  no           Negate a command or set its defaults
  prefix-list  Build a prefix list
  route-map    Create route-map or enter route-map command
   mode
  router       Enable a routing process
  show         Show running system information
  stop         stop
RIP(config)# interface?
  IFNAME  Interface's name
RIP(config)# interface eth0
RIP(config-if)#?
  authentication  Authentication control
  description     Interface specific description
  end             End current mode and change to root mode
   (CTRL+C).
  exit            Back to WANFleX command shell (CTRL+D).
  help            Print command list
  no              Negate a command or set its defaults
  receive         Advertisement reception
  send            Advertisement transmission
```

```
  show              Show running system information
  split-horizon     Perform split horizon
RIP(config-if)#
```

After quitting CS using "exit" command (or Ctrl+D), CS stays in the last active mode.

Commands may have different parameters. Commands parameters are specified in several formats. Parameter's format is described in the context help or in the list of commands (**help** command) in the following way:

- A.B.C.D - a parameter is set in IP-address format. Example: 192.168.0.15
- WORD - a set of characters with no spaces
- <1-N> - a parameter is set as a decimal number in a range from 1 to N
- A.B.C.D/M - a parameter is set in a format IP-address/subnet mask length. Example: 192.168.0.0/24
- IFNAME - name of a physical network interface. Example: **eth0**

If a parameter can be written in different formats, it will be displayed in round brackets, the options are separated by "|" character. Example: **(A.B.C.D|<0-4294967295>)**.

If a parameter is optional, it is put into square brackets: "**[]**".

Any command may contain "**no**" prefix. Having this prefix in the command means deleting a corresponding parameter from the configuration.

4.5.3 Start/Stop of RIP

Start of RIP router is executed by the following command:

```
RIP start
```

In order to stop RIP, execute the following command in config mode:

```
stop (daemon|clear)
```

Example:

```
> arip
RIP> configure
RIP(config)# stop daemon
```

If "stop" command is executed with clear parameter, the router will clear its part of the system configuration prior to quitting CS.

4.5.4 Filters

In many participating in the configuration parameters of the device filters are used. Filters are represented by two classes of objects:

- Access lists (access-list)
- Prefixes lists (prefix-list)

Access lists consist of a set of operators. Each operator consists of a range of IP-addresses and *deny* or *permit* command. The range of addresses is set as <value> <mask for insignificant bits>. The object to be filtrated has its basic parameter in the same format (IP-address, subnet etc). To make a decision whether the object corresponds with a list, each operator from the list is consequently applied to the basic parameter of the object until this parameter satisfies the condition. When a right condition is met, the decision is made according to the record in the command of the operator (*deny* or *permit*).

In RIP router there are three types of access lists:

- Standard. Is identified by numbers 1-99 or 1300-1999 and is used to analyze one parameter of filtration object.
- Extended. Is identified by numbers 100-199 or 2000-2699 and is used to analyze two parameters of filtration object (for example, source address and destination address).
- Nominate. Identical to Standard but is identified by a name (not number). Moreover, operators are configured in the format of <value>/<mask length>

In order to create or edit an access list in RIP router the following commands are used (in *config* mode):

Table 4-2: Standard Access Lists

access-list	(<1-99>|<1300-1999>)	(deny|permit)	A.B.C.D	A.B.C.D
	List identifier	Command	value	Mask of bits
			Range of values for the parameter	

This command creates an operator in a standard access list. Value and mask define a range (criteria) for the operator. The mask defines those bits of the value which form the range. For example, in order to specify the range of IP-address from 192.168.12.0 to 192.168.255, one should specify the value of 192.168.12.0 and a mask of 0.0.0.255. For the value and mask of 0.0.0.0 255.255.255.255 there is a key word *any*. For example, the command:

```
RIP(config)# access-list 1 permit 0.0.0.0 255.255.255.255
```

is equal to the command:

```
RIP(config)# access-list 1 permit any
```

Correspondingly, for the range which consists of only one address, the key word *host* is used.

For example, the command:

```
RIP(config)# access-list 1 permit 192.168.12.150 0.0.0.0
```

is equal to the following command:

```
RIP(config)# access-list 1 permit host 192.168.12.150
```

Table 4-3: Extended Access Lists

access-list	(<100-199>|<2000-2699>)	(deny|permit)	ip	A.B.C.D A.B.C.D	A.B.C.D A.B.C.D.
	List identifier	command		The range of source addresses	The range of destination addresses

Table 4-4: Nominate Access Lists

access-list	WORD	(deny|permit)	A.B.C.D/M	[exact-match]
	List identifier	command	Range	The requirement for the exact match of a parameter to the range

In this case the list identifier is a character expression. The range is specified in a format of <value>/<mask length>. For example, if we need to specify the range of IP-addresses from 192.168.12.0 to 192.168.12.255, 192.168.12.0/24 is specified. For 0.0.0.0/0 range the key word *any* can be used. For example:

```
RIP(config)# access-list TestList1 deny 192.168.1.0/24
RIP(config)# access-list TestList1 permit any
```

While configuring, the operators are appended to the end of the list.

Lists of prefixes are different from access lists so that each operator has a number aside from a range (condition). Moreover, when a check for the parameter to fit into an operator's range is performed, one can set up additional condition for the parameter's mask length.

Table 4-5: Prefix Lists

prefix-list	WORD	[seq <1-4294967295>]	(deny|permit)	A.B.C.D/M	[ge <0-32>] [le <0-32>]
	List identifier	Operator's position number	Command	Range	The range of the permitted mask length

If a sequential number is not specified the router sets it up automatically by adding 5 to the number of the last operator in a list. Thus, the operator will have the biggest number and will be placed in the end of the list.

4.5.5 RIP configuration

The router can be enabled on the interface in several ways:

1 *By network specification.* RIP will be enabled on the interface with network address matching with the specified network. This can be performed by the following command in the *config-router* mode:

```
network A.B.C.D/M
```

Network is specified by its IP-prefix and mask.

2 By interface name. RIP will be enabled on the specified interface. This can be performed by the following command in the config-router mode:

```
network WORD
```

where **WORD** is interface name.

Example:

```
RIP>configure
RIP(config)# router
RIP(config-router)# network 4.7.8.0/24
RIP(config-router)# network  rf5.0
RIP(config-router)#
```

To cancel RIP on the interfacer use command:

```
no network A.B.C.D/M
no network WORD
```

In some cases not all routers understand multicast requests. To solve this problem, you can establish a direct link between routers. To implement this, use the command in config-router mode:

```
neighbor a.b.c.d
```

a.b.c.d - router's neighbor address. To cancel link between routers:

```
no neighbor a.b.c.d
```

To announce information from other routing protocols use the following command in config-router mode:

```
redistribute (kernel|connected|static|ospf) [metric
   <0-16777214>] [metric-type (1|2)] [route-map WORD]
```

To define criteria according to which a router will announce information from some routing protocol, use the command in config-router mode:

```
distribute-list WORD direct ifname
```

where **WORD** - list name, **direct** - direction (values "**in**" or "**out**". When **direct** is "**in**" access list is adjusted to input packages, when "**out**" - to output packages). This command connects access list with the interface.

In the following example, the "eth0" allows only those packets that are routed to 10.0.0.0/8:

```
RIP(config-router)# distribute-list private in eth0
RIP(config-router)# access-list private permit 10 10.0.0.0/8
RIP(config-router)# access-list private deny any
```

Default metric is specified using the following command in the config-router mode:

```
default-metric <0-16>
```

If default metric is not defined, it equals 1.

In **redistribute kernel** mode the router will not make an advertisement into RIP system about having as link to *default gateway* (destination = 0.0.0.0/0 network), even if it is clearly written in the routing table by the administrator. In order for the router to advertise its link to the *default gateway* it is necessary to clearly force him to do that using a command in *config-router* mode:

```
default-information originate [always] [metric-type (1|2)]
   [metric <0-16777214>] [route-map WORD]
```

metric-type (1|2) and **metric <0-16777214>** attributes define the same parameters of the external link for **redistribute** command. They are also not

mandatory. This command also has one optional attribute - **always**. This attribute makes a router to advertise its *default gateway* link even if the route is not in the routing table.

To cancel advertising of an external link to *default gateway* us the command:

```
no default-information originate
```

The following command enables "split horizon" algorithm at the device's ip interface in the *config-if* mode:

```
split-horizon [poisoned-reverse]
```

When the "split horizon" algorithm is enabled device doesn't announce routes through an interface from which they were obtained, thus reducing the likelihood of a local routing cycles.

If **poisoned-reverse** option is set device when removing the route still some time left it in the routing table and include it in the standard distribution announcement with special reference so that neighboring routers realize that the route is no longer used. Metrics of a route with the value 16 is used as a metrics for this.

"Split horizon" algorithm without **poisoned-reverse** option is enabled by default.

To cancel "split horizon" algorithm use command:

```
no split-horizon
```

4.5.6 Route Map (route-map)

For more flexible configuration of metric type and its value, one can use a route-map. Route-map is a set of conditional records. Each record has its number in the map, a condition of correspondence for the importing route of the record, actions to be done with a resulting object in case of its correspondence, resulting action (deny, permit) etc. Routes are listed in the route-map according to their number in ascending order. If a route satisfies a record's condition:

- If a resulting action is **deny**, the route is denied, review of map's records is aborted and a resulting object is cancelled (link is not advertised)

- If a resulting action is **permit**, all actions specified in the record are performed for a resulting object. Further, records viewing is stopped or, if specified in the scenario, it is resumed depending on the option specified in the scenario:

  1. **on-match next** - viewing is continued from the record which follows a current record

2 **on-match goto <N>** - viewing is continued from the record which number is more or equal **N** but is not less than current number.

In order to configure a route-map, the following command is used in *config* mode:

```
route-map WORD (deny|permit) <1-65535>
```

where **WORD** - route-map identifier. This identifier is followed by a resulting action and the number of the record. If a record with a specified number does not exist it will be automatically created. After executing this command, CS switched to the mode for editing a selected route-map. For example:

```
RIP> configure
RIP(config)# route-map testmap permit 10
RIP(config-route-map)#
```

After that, a condition of match between imported route and current record is specified. The following commands are used in config-route-map mode:

```
match address (<1-199>|<1300-2699>|WORD)
match address prefix-list WORD
match interface WORD
match next-hop (<1-199>|<1300-2699>|WORD)
match next-hop prefix-list WORD
```

These commands set matching conditions for the route according to three different parameters: destination, gateway (next hop) and interface. For every record it is permitted to set a number of different conditions. If several conditions are specified they will be conjugated by logical "and". In **match next-hop** and **match address command** a filtration object is specified (number or name): number or name of **access-list** or **prefix-list** name. In this case the condition will be satisfied if a corresponding route's parameter belongs to the specified filtering list, according to the rule corresponding to the list type. In **match interface** command a network interface name is specified to which a route belongs.

If a route matches to all record's rules one can set values for route metric and/or metric type for this router using commands in *config-route-map* mode:

```
set metric <0-4294967295>
set metric-type (type-1|type-2)
```

The next step for the record's behavior, after all conditions are matched by the route, can be configured using one of the following commands:

```
on-match goto <1-65535>
```

```
on-match next
```

Configuration example:

```
RIP> configure
RIP(config)# access-list AnyNetwork permit any
RIP(config)# access-list net200 permit 192.168.200.0/24
RIP(config)# route-map mapForConnected permit 10
RIP(config-route-map)# match address net200
RIP(config-route-map)# set metric 7
RIP(config-route-map)# route-map mapForConnected deny 11

RIP(config-route-map)# match address AnyNetwork
RIP(config-route-map)# router
RIP(config-router)# redistribute connected route-map
   mapForConnected
RIP(config-route-map)#
```

In this configuration the router will announce route formed from the connected routes of the system routing table with metric type 2. With this, if a destination for this route is 192.168.200.0/24 network the formed route will have metric 7, any other destination will not lead to route announcing it.

Attention!!! For the interface to use the route-map which we have created before one have to use command route-map in the config-router mode:

```
route-map WORD (in|out) IFNAME
```

where **WORD** - name of the road-map which we have created before.

4.5.7 Authentication. Identity Check

In order to prevent an unauthorized connection of the routers to RIP system, the system has an identity check for protocol's packets. Currently the router has two different options for identity check (authentication):

- **Password authentication**. Simple password authentication is vulnerable for passive attacks (sniffing) because broadcasting is used and the packet has a password in an explicit form.

- **Cryptographic authentication**. Key is used while generation and check of message-digest signatures. Digital signature is built based on MD5 algorithm. As a secret key is never send over the network in a clear form, this gives a protection from passive attacks.

By default, the router does not have any authentication (null-authentication).

Authentication can be configured individually for each interface using the following commands in *config-if* mode:

1 Password authentication:

```
authentication mode text
authentication string LINE
```

where **LINE** - password, less than 16 symbols.

2 Cryptographic authentication:

```
authentication mode md5
authentication key-chain LINE
```

where **LINE** - name of the secret MD5 key

To configure the key which name is specified in **LINE** parameter use command in config mode:

```
RIP(config)# key chain WORD
RIP(config-keychain)# key <0-2147483647>
RIP(config-keychain-key)# key-string LINE
```

where

WORD - key chain name

<0-2147483647> - key ID

LINE - secret md5 key

4.5.8 Timers Configuration

RIP protocol has several timers. User can configure those timers' values by timer's basic command. The default settings for the timers are as follows:

- The **update timer** is 30 seconds. Every update timer seconds, the RIP process is awakened to send an unsolicited Response message containing the complete routing table to all neighboring RIP routers.

- The **timeout timer** is 180 seconds. Upon expiration of the timeout, the route is no longer valid; however, it is retained in the routing table for a short time so that neighbors can be notified that the route has been dropped.

- The **garbage collect timer** is 120 seconds. Upon expiration of the garbagecollection timer, the route is finally removed from the routing table.

The following command in config-router mode allows the default values of the timers listed above to be changed:

```
timers basic update timeout garbage
```

The no timers basic command will reset the timers to the default settings listed above:

```
no timers basic
```

4.5.9 Configuration View

To review RIP configuration there are several commands in the basic mode of CS:

```
show access-list
```

This command shows information about access lists.

```
show memory
```

This command shows information about memory usage.

```
show rip
```

This command shows current RIP configuration. Viewing Information about timers, filters, version, interfaces, on which RIP is enabled.

```
show route
```

This command lists route table.

4.6 ARDA

4.6.1 Getting Started

ARDA is a daemon that does interconnection between RIP and OSPF regarding routing processes.

ARDA configuration is performed by "**arda**" command.

4.6.2 Command Language. Basic Principles

ARDA has its own command shell (CS). To enter the shell, execute the following command:

```
#1> arda
ARDA>
```

Commands entered in CS are not case-sensitive and can be shortened until ambiguity appears. To get a quick hint you can press "?" at any time:

```
ARDA>?
  configure  Configuration from vty interface
  end        End current mode and change to root mode
   (CTRL+C).
  exit       Back to WANFleX command shell (CTRL+D).
  help       Print command list
  show       Show running system information
```

CS can work in different modes. Current mode is displayed along with command prefix as "ARDA(mode)#". For example, if **configure** command is entered, CS switches to "config" mode:

```
ARDA> configure
ARDA(config)#
```

One can set the necessary mode or execute commands without specially entering into ARDA module. For example, if we consistently execute the following commands:

```
#1> arda configure
#1> arda
ARDA(config)#
```

while entering arip we will enter directly into necessary mode "*config*" (as it is shown in the example).

Every mode has its own set of commands. The following commands are available in any mode:

- **Help** - prints the list of commands for the current mode
- **End** - goes back from the current mode to the base mode
- **No** - negate a command or set its defaults
- **Exit** - exit to WANFleX CLI from ARDA CS

At the start, CS is in the base mode which has a set of commands to view current ARDA state.

After quitting CS using "exit" command (or Ctrl+D), CS stays in the last active mode.

Commands may have different parameters. Commands parameters are specified in several formats. Parameter's format is described in the context help or in the list of commands (**help** command) in the following way:

- A.B.C.D - a parameter is set in IP-address format. Example: 192.168.0.15
- WORD - a set of characters with no spaces
- <1-N> - a parameter is set as a decimal number in a range from 1 to N
- A.B.C.D/M - a parameter is set in a format IP-address/subnet mask length. Example: 192.168.0.0/24
- ITERFACE - name of a physical network interface. Example: **eth0**

If a parameter can be written in different formats, it will be displayed in round brackets, the options are separated by "|" character. Example: **(A.B.C.D|<0-4294967295>)**.

If a parameter is optional, it is put into square brackets: "**[]**".

Any command may contain "**no**" prefix. Having this prefix in the command means deleting a corresponding parameter from the configuration.

4.6.3 Start/Stop of ARDA

Start of ARDA is executed by the following command:

```
ARDA start
```

In order to stop ARDA, execute the following command in "config" mode:

```
stop (daemon|clear)
```

Example:

```
> arda

ARDA> configure

ARDA(config)# stop daemon
```

If "stop" command is executed with clear parameter, the device will clear its part of the system configuration prior to quitting CS.

4.6.4 Filters

In many participating in the configuration parameters of the device filters are used. Filters are represented by two classes of objects:

- Access lists (access-list)
- Prefixes lists (prefix-list)

Access lists consist of a set of operators. Each operator consists of a range of IP-addresses and *deny* or *permit* command. The range of addresses is set as <value> <mask for insignificant bits>. The object to be filtrated has its basic parameter in the same format (IP-address, subnet etc). To make a decision whether the object corresponds with a list, each operator from the list is consequently applied to the basic parameter of the object until this parameter satisfies the condition. When a right condition is met, the decision is made according to the record in the command of the operator (*deny* or *permit*).

In ARDA there are three types of access lists:

- Standard. Is identified by numbers 1-99 or 1300-1999 and is used to analyze one parameter of filtration object.
- Extended. Is identified by numbers 100-199 or 2000-2699 and is used to analyze two parameters of filtration object (for example, source address and destination address).

- Nominate. Identical to Standard but is identified by a name (not number). Moreover, operators are configured in the format of <value>/<mask length>

In order to create or edit an access list in ARDA the following commands are used (in "*config*" mode):

Table 4-6: Standard Access Lists

access-list	(<1-99>|<1300-1999>)	(deny|permit)	A.B.C.D	A.B.C.D
	List identifier	Command	value	Mask of bits
			Range of values for the parameter	

This command creates an operator in a standard access list. Value and mask define a range (criteria) for the operator. The mask defines those bits of the value which form the range. For example, in order to specify the range of IP-address from 192.168.12.0 to 192.168.255, one should specify the value of 192.168.12.0 and a mask of 0.0.0.255. For the value and mask of 0.0.0.0 255.255.255.255 there is a key word any. For example, the command:

```
ARDA(config)# access-list 1 permit 0.0.0.0 255.255.255.255
```

is equal to the command:

```
ARDA(config)# access-list 1 permit any
```

Correspondingly, for the range which consists of only one address, the key word "*host*" is used.

For example, the command:

```
ARDA(config)# access-list 1 permit 192.168.12.150 0.0.0.0
```

is equal to the following command:

```
ARDA(config)# access-list 1 permit host 192.168.12.150
```

Table 4-7: Extended Access Lists

access-list	(<100-199>|<2000-2699>)	(deny|permit)	ip	A.B.C.D A.B.C.D	A.B.C.D A.B.C.D.
	List identifier	command		The range of source addresses	The range of destination addresses

Table 4-8: Nominate Access Lists

access-list	WORD	(deny|permit)	A.B.C.D/M	[exact-match]
	List identifier	command	Range	The requirement for the exact match of a parameter to the range

In this case the list identifier is a character expression. The range is specified in a format of <value>/<mask length>. For example, if we need to specify the range of IP-addresses from 192.168.12.0 to 192.168.12.255, 192.168.12.0/24 is specified. For 0.0.0.0/0 range the key word *any* can be used. For example:

```
ARDA(config)# access-list TestList1 deny 192.168.1.0/24

ARDA(config)# access-list TestList1 permit any
```

While configuring, the operators are appended to the end of the list.

4.6.5 Creating Static Routes

To create a static route in the system using ARDA use "route" command in "configuration" mode:

```
ARDA(config)# route <destination IP> [/] <mask><gateway>
   <reject|blackhole> <1-255>
```

Where:

- **Destination IP** - sets IP-address of the destination device. Can be set in various ways described in "Basic principles" and "Filters" parts.
- **Mask** - sets network mask for destination device. Can be set in various ways described in "Basic principles" and "Filters" parts.
- **Gateway** - sets IP gateway address or device interface as IP gateway
- **Reject** - emits an ICMP unreachable message when matched for the defined route
- **Blackhole** - Silently discards packets when matched for the defined route
- **<1-255>** - sets route priority

Examples:

```
ARDA(config)# route 10.1.2.3/24 eth0

ARDA(config)# route 10.1.2.3/24 1.2.3.1 reject
```

```
ARDA(config)# route 10.1.2.3/24 eth0 5
```

4.6.6 Interface Management

To manage a specific interface in ARDA "interface" command in "configuration" mode:

```
ARDA(config)# interface <INTERFACE NAME>
```

The following options are available for configuration:

- **Bandwidth** - sets bandwidth in Bits per second.
- **Link-detect** - enables automatic link detection
- **Gateway** - sets IP gateway address or device interface as IP gateway
- **Show running-config** - shows ARDA interfaces configuration

Examples:

```
ARDA(config-if)# bandwidth 100000
ARDA(config-if)# show running-config
```

4.6.7 Configuration View

To review ARDA configuration there are several commands in the basic mode of CS:

```
show access-list
```

This command shows information about access lists.

```
show memory
```

This command shows information about memory usage.

```
show arda
```

This command shows current ARDA configuration

```
show route
```

This command lists route table

4.7 OSPFv2 (Dynamic Routing Protocol Module)

4.7.1 Getting Started

OSPF protocol is widely used routing protocol for IP networks. Basic principles that form a current version of protocol are outlined in RFC 2328. OSPF protocol is a classical Link-State protocol which delivers the following functionality:

- no limitation for the network size
- routes information update sending using multicast addresses
- high speed route definition
- using authentication procedure while routes updating
- classless routing support

4.7.2 Command Language. Basic Principles

OSPF has its own command shell (CS). To enter the shell, execute the following command:

```
#1> ospf
OSPF>
```

Commands entered in CS are not case-sensitive and can be shortened until ambiguity appears. To get a quick hint you can press "?" at any time:

```
OSPF>?
  configure  Configuration from vty interface
  end        End current mode and change to root mode
   (CTRL+C).
  exit       Back to WANFleX command shell (CTRL+D).
  help       Print command list
  show       Show running system information
OSPF>
```

CS can work in different modes. Current mode is displayed along with command prefix as "OSPF(mode)#". For example, if **configure** command is entered, CS switches to *config* mode:

```
OSPF> configure

OSPF(config)#
```

The following figure shows the transition scheme between different modes of CS.

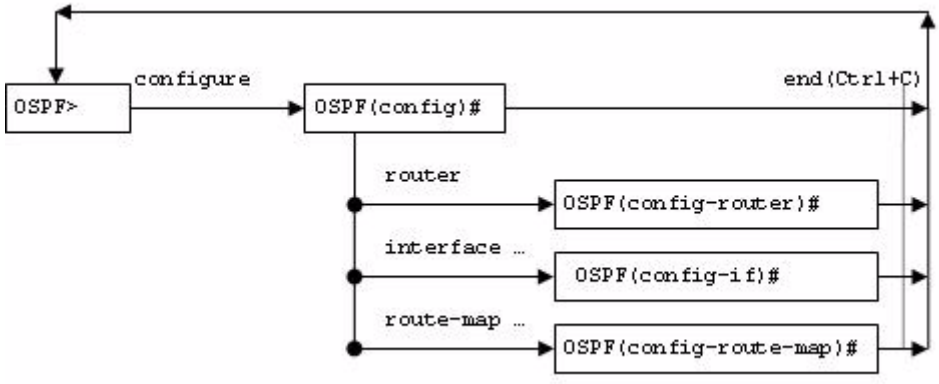

Figure 4-5: OSPF Transition

Every mode has its own set of commands. The following commands are available in any mode:

- Help - prints the list of commands for the current mode
- Alias - sets symbolic name for the current configurable parameter
- End - goes back from the current mode to the base mode
- Exit - exit to WANFleX CLI from OSPF CS

Debug level command sets debugging level from 0 to 255.

At the start, CS is in the base mode which has a set of commands to view current router state. In order to switch to the configuration mode you should have *superuser* rights. After entering a configuration mode, the configuration is being blocked and entering in this mode from other terminal (e.g. other telnet session) is prohibited. In order to avoid a "dead" block of the session, CS automatically quits the configuration mode after five minutes of no activity.

Context help is always available using "?". For example:

```
OSPF> config
OSPF(config)#?
  access-list  Add an access list entry
  alias        Set symbolic mode
  clear        Reset functions
  debug        Set debugging print level
  end          End current mode and change to root mode
   (CTRL+C).
  exit         Back to WANFleX command shell (CTRL+D).
  help         Print command list
  interface    Select an interface to configure
  no           Negate a command or set its defaults
  prefix-list  Build a prefix list
  route-map    Create route-map or enter route-map command
   mode
  router       Enable a routing process
  show         Show running system information
  stop         stop
OSPF(config)# interface?
  IFNAME  Interface's name
OSPF(config)# interface eth0
OSPF(config-if)#?
  authentication       Enable authentication on this interface
  authentication-key   Authentication password (key)
  cost                 Interface cost
  dead-interval        Interval after which a neighbor is
   declared dead
  description          Interface specific description
  end                 End current mode and change to root mode
   (CTRL+C).
  exit                 Back to WANFleX command shell (CTRL+D).
  hello-interval       Time between HELLO packets
```

```
  help                    Print command list
  message-digest-key      Message digest authentication password
   (key)
  mtu <40-65535>
  network                 Network type
  no                      Negate a command or set its defaults
  priority                Router priority

  retransmit-interval     Time between retransmitting lost link
   state
  show                    Show running system information
  transmit-delay          Link state transmit delay
OSPF(config-if)#
```

After quitting CS using "exit" command (or Ctrl+D), CS stays in the last active mode.

Commands may have different parameters. Commands parameters are specified in several formats. Parameter's format is described in the context help or in the list of commands (**help** command) in the following way:

- A.B.C.D - a parameter is set in IP-address format. Example: 192.168.0.15
- WORD - a set of characters with no spaces
- <1-N> - a parameter is set as a decimal number in a range from 1 to N
- A.B.C.D/M - a parameter is set in a format IP-address/subnet mask length. Example: 192.168.0.0/24
- IFNAME - name of a physical network interface. Example: **eth0**

If a parameter can be written in different formats, it will be displayed in round brackets, the options are separated by "|" character. Example: **(A.B.C.D|<0-4294967295>)**.

If a parameter is optional, it is put into square brackets: "**[]**".

Any command may contain "**no**" prefix. Having this prefix in the command means deleting a corresponding parameter from the configuration.

4.7.3 Start/Stop of OSPF

Start of OSPF router is executed by the following command:

```
ospf start
```

In order to stop OSPF, execute the following command in config mode:

```
stop (daemon|clear)
```

Example:

```
>ospf
OSPF> configure
OSPF(config)# stop daemon
```

If "stop" command is executed with clear parameter, the router will clear its part of the system configuration prior to quitting CS.

4.7.4 Router Identifier

Every OSPF router has a unique identifier. Identifier is a 32-bit integer. In order to assign an identifier, execute the following command in config-router mode:

```
router-id A.B.C.D
```

Example:

```
OSPF>configure
OSPF(config)# router
OSPF(config-router)# ospf router-id 195.38.45.107
OSPF(config-router)#
```

If identifier was not set by administrator, the router will automatically assign an identifier which equals to a maximal (by value) IP-address from all IP-addresses participating in OSPF system.

To cancel identifier assigning, use the following command:

```
no router-id
```

4.7.5 Filters

In many parameters of the router participating in the configuration filters are used. Filters are represented by two classes of objects:

- Access lists (access-list)

- Prefixes lists (prefix-list)

Access lists consist of a set of operators. Each operator consists of a range of IP-addresses and *deny* or *permit* command. The range of addresses is set as <value> <mask for insignificant bits>. The object to be filtrated has its basic parameter in the same format (IP-address, subnet etc). To make a decision whether the object corresponds with a list, each operator from the list is consequently applied to the basic parameter of the object until this parameter satisfies the condition. When a right condition is met, the decision is made according to the record in the command of the operator (*deny* or *permit*).

In OSPF router there are three types of access lists:

- Standard. Is identified by numbers 1-99 or 1300-1999 and is used to analyze one parameter of filtration object.

- Extended. Is identified by numbers 100-199 or 2000-2699 and is used to analyze two parameters of filtration object (for example, source address and destination address).

- Nominate. Identical to Standard but is identified by a name (not number). Moreover, operators are configured in the format of <value>/<mask length>

In order to create or edit an access list in OSPF router the following commands are used (in config mode):

Table 4-9: Standard Access Lists

access-list	(<1-99>|<1300-1999>)	(deny|permit)	A.B.C.D	A.B.C.D
	List identifier	Command	value	Mask of bits
			Range of values for the parameter	

This command creates an operator in a standard access list. Value and mask define a range (criteria) for the operator. The mask defines those bits of the value which form the range. For example, in order to specify the range of IP-address from 192.168.12.0 to 192.168.255, one should specify the value of 192.168.12.0 and a mask of 0.0.0.255. For the value and mask of 0.0.0.0 255.255.255.255 there is a key word *any*. For example, the command:

```
OSPF(config)# access-list 1 permit 0.0.0.0 255.255.255.255
```

is equal to the command:

```
OSPF(config)# access-list 1 permit any
```

Correspondingly, for the range which consists of only one address, the key word *host* is used.

For example, the command:

```
OSPF(config)# access-list 1 permit 192.168.12.150 0.0.0.0
```

is equal to the following command:

```
OSPF(config)# access-list 1 permit host 192.168.12.150
```

Table 4-10: Extended Access Lists

access-list	(<100-199>|<2000-2699>)	(deny|permit)	ip	A.B.C.D A.B.C.D	A.B.C.D A.B.C.D.
	List identifier	command		The range of source addresses	The range of destination addresses

Table 4-11: Nominate Access Lists

access-list	WORD	(deny|permit)	A.B.C.D/M	[exact-match]
	List identifier	command	Range	The requirement for the exact match of a parameter to the range

In this case the list identifier is a character expression. The range is specified in a format of <value>/<mask length>. For example, if we need to specify the range of IP-addresses from 192.168.12.0 to 192.168.12.255, 192.168.12.0/24 is specified. For 0.0.0.0/0 range the key word *any* can be used. For example:

```
OSPF(config)# access-list TestList1 deny 192.168.1.0/24
OSPF(config)# access-list TestList1 permit any
```

While configuring, the operators are appended to the end of the list.

Lists of prefixes are different from access lists so that each operator has a number aside from a range (condition). Moreover, when a check for the parameter to fit into an operator's range is performed, one can set up additional condition for the parameter's mask length.

Table 4-12: Prefix Lists

prefix-list	WORD	[seq <1-4294967295>]	(deny|permit)	A.B.C.D/M	[ge <0-32>] [le <0-32>]
	List identifier	Operator's position number	Command	Range	The range of the permitted mask length

If a sequential number is not specified the router sets it up automatically by adding 5 to the number of the last operator in a list. Thus, the operator will have the biggest number and will be placed in the end of the list.

4.7.6 Link State Advertisement

The router can advertise its link states of two types:

1. *Internal links*. These are links which destinations are addresses of the subnets to which a router is connected directly (using one of its network interfaces) and which are described in OSPF router configuration.
2. *External links*. Links which destinations are route's destinations configured in WANFleX. These can be static routes (**route add (kernel)**) or routes which appear in the routing table by assigning IP-address (alias) to one of physical network interfaces (**connected**).

In order to advertise an internal link, a subnet should be specified which destination is an advertised link. This can be done in *config-router* mode:

```
network A.B.C.D/M area (A.B.C.D|<0-4294967295>)
```

Network is specified by router's IP-address/mask which belongs to this network. Area ID can be inputted either in IP-addresses format or in decimal number format.

Example:

```
OSPF>configure
OSPF(config)# router
OSPF(config-router)# network 4.7.8.32/24 area 0.0.0.1
OSPF(config-router)# network 192.168.15.1/24 area 0
OSPF(config-router)#
```

If none of router's network interfaces has an IP-address from specified subnet, OSPF will not advertise this link although this network will be in configuration (inactive link).

Thus, the router obtains an internal link (for OSPF system) for which a given network is a destination. If this network is a physical interface address (point-to-point) the router gets an internal link with a router ID destination which is connected on the opposite end of point-to-point link.

To cancel internal link advertising use the command:

```
no network A.B.C.D/M area (A.B.C.D|<0-4294967295>)
```

In some cases there is a necessity to advertise internal links automatically for the selected network interface. It becomes important when IP-addresses of this interface (aliases) are created and deleted automatically, for example, when CPEs are connecting to the BS via radio. To implement this, use the command in *config-router* mode:

```
auto-interface IFNAME area (A.B.C.D|<0-4294967295>)
```

In the command an area ID is specified to which networks (destinations) will be deferred. To cancel an automatic links advertisement for this interface, use the command in *config-router* mode:

```
no auto-interface IFNAME
```

To announce external links use the following command in config-router mode:

```
redistribute (kernel|connected|static) [metric <0-16777214>]
   [metric-type (1|2)] [route-map WORD]
```

To define criteria according to which a router will advertise the link, use the command in config-router mode:

```
distribute-list WORD out (kernel|connected|static)
```

If this filter is not defined the router will advertise all links of the specified type of a system table, if they are not dejected by route-map configured in **redistribute** command parameters.

All links of this type are advertised as external type links with metric type 1 or 2 (External Type1|2). Information about external links is spread all over OSPF domain (not only in the area). Stub areas are an exception to which the information about external links is advertised as default gateway through the area border router (ABR) of the area. Two types of metric differ in a way that metric type 1 is a metric which is "commensurable" with inner OSPF links. When calculating a metric to the external destination, the full path metric is calculated as a sum of a path metric of a router which had advertised this link plus the link metric. Thus, a route with the least summary metric will be selected. If external link is advertised with metric type 2 the path is selected which lies through the router which advertised this link with the least metric despite of the fact that internal path to this router is longer (with more cost). However, if two routers advertised an external link and with metric type 2 the preference is given to the path which lies through the router with a shorter internal path. If two different routers advertised two links to the same external destination but with different metric type, metric type 1 is preferred.

WORD - access list identifier to which destination of system routing table should respond.

Value and type of a metric for external links can be defined in route-map. In this case a type and value of a metric can be defined depending on route parameters (interface, gateway, destination etc).

If type and/or value of a metric left undefined the router will consider these external links to have a default metric and type 2. Default metric is specified using the following command:

```
default-metric <0-16777214>
```

If default metric is not defined, it equals 1.

In **redistribute kernel** mode the router will not make an advertisement into OSPF system about having as link to *default gateway* (destination = 0.0.0.0/0 network), even if it is clearly written in the routing table by the administrator. In order for the router to advertise its link to the *default gateway* it is necessary to clearly force him to do that using a command in *config-router* mode:

```
default-information originate [always] [metric-type (1|2)]
   [metric <0-16777214>] [route-map WORD]
```

metric-type (1|2) and **metric <0-16777214>** attributes define the same parameters of the external link for **redistribute** command. They are also not mandatory. This command also has one optional attribute - **always**. This attribute makes a router to advertise its *default gateway* link even if the route is not in the routing table.

To cancel advertising of an external link to *default gateway* us the command:

```
no default-information originate
```

4.7.6.1 Route map (route-map)

For more flexible configuration of metric type and its value for external links, one can use a route-map. Route-map is a set of conditional records. Each record has its number in the map, a condition of correspondence for the importing route of the record, actions to be done with a resulting object in case of its correspondence, resulting action (deny, permit) etc. Routes are listed in the route-map according to their number in ascending order. If a route satisfies a record's condition:

- If a resulting action is **deny**, the route is denied, review of map's records is aborted and a resulting object is cancelled (link is not advertised)
- If a resulting action is **permit**, all actions specified in the record are performed for a resulting object. Further, records viewing is stopped or, if specified in the scenario, it is resumed depending on the option specified in the scenario:

1. **on-match next** - viewing is continued from the record which follows a current record
2. **on-match goto <N>** - viewing is continued from the record which number is more or equal **N** but is not less than current number.

In order to configure a route-map, the following command is used in config mode:

```
route-map WORD (deny|permit) <1-65535>
```

where **WORD** - route-map identifier. This identifier is followed by a resulting action and the number of the record. If a record with a specified number does not exist it will be automatically created. After executing this command, CS switched to the mode for editing a selected route-map. For example:

```
OSPF> configure
OSPF(config)# route-map testmap permit 10
OSPF(config-route-map)#
```

After that, a condition of match between imported route and current record is specified. The following commands are used in config-route-map mode:

```
match address (<1-199>|<1300-2699>|WORD)
match address prefix-list WORD
match interface WORD
match next-hop (<1-199>|<1300-2699>|WORD)
match next-hop prefix-list WORD
```

These commands set matching conditions for the route according to three different parameters: destination, gateway (next hop) and interface. For every record it is permitted to set a number of different conditions. If several conditions are specified they will be conjugated by logical "and". In **match next-hop** and **match address command** a filtration object is specified (number or name): number or name of **access-list** or **prefix-list** name. In this case the condition will be satisfied if a corresponding route's parameter belongs to the specified filtering list, according to the rule corresponding to the list type. In **match interface** command a network interface name is specified to which a route (link) belongs.

If a route matches to all record's rules one can set values for route metric and/or metric type for a link which if formed from this router using commands in *config-route-map* mode:

```
set metric <0-4294967295>
set metric-type (type-1|type-2)
```

The next step for the record's behavior, after all conditions are matched by the route, can be configured using one of the following commands:

```
on-match goto <1-65535>

on-match next
```

Configuration example:

```
OSPF> configure

OSPF(config)# access-list AnyNetwork permit any

OSPF(config)# access-list net200 permit 192.168.200.0/24

OSPF(config)# route-map mapForConnected permit 10

OSPF(config-route-map)# match address net200

OSPF(config-route-map)# set metric 7

OSPF(config-route-map)# route-map mapForConnected deny 11

OSPF(config-route-map)# match address AnyNetwork

OSPF(config-route-map)# router

OSPF(config-router)# redistribute connected route-map
   mapForConnected

OSPF(config-route-map)#
```

In this configuration the router will advertise external links formed from the connected routes of the system routing table with metric type 2. With this, if a destination for this route is 192.168.200.0/24 network the formed link will have metric 7, any other destination will not lead to external link's advertising it.

4.7.7 Link Metric

Link metric is a cost of traffic delivery through its network interface. OSPF router automatically calculates the cost of internal link taking physical interface's capacity to which link belongs into consideration:

M = reference_bandwidth/bandwidth.

reference_bandwidth - by default equals 100 Mbit/sec, **bandwidth** - a capacity (bandwidth) of a physical network interface to which the link belongs. Reference bandwidth can be modified using the following command in *config-router* mode:

```
auto-cost reference-bandwidth <1-4294967>
```

The parameter is specified in Mbit/sec.

A method for metric configuration described above is used for all links for which interfaces a specific cost is not set. To set an individual cost (metric) for links one can using the following command in *config-if* mode:

```
cost <1-65535> [A.B.C.D]
```

In order to get into *config-if* mode for the particular interface, the following command is used:

```
interface IFNAME
```

Example:

```
OSPF> configure

OSPF(config)# interface eth0

OSPF(config-if)# cost 4 192.168.15.1

OSPF(config-if)#
```

In **cost** command an IP-address is specified which is assigned to the interface in a subnet which is connected to this subnet. If this parameter is not specified every link for this interface will have a specified cost (metric) regardless from the destination subnet.

4.7.8 OSPF System Areas

OSPF protocol has an ability to join adjacent networks and hosts into special groups. This group along with a router that has a link to one (any) of the networks included into the group is called an *area*. In each area an independent copy of OSPF is functioning. That means that each area has its own database and a corresponding graph.

A router that is configured to advertise only internal links is called an internal router (IR). A router connected to networks in more that one area is called *area border router (ABR)*. A router that advertises its link to external destinations (**redistribute command**) is called AS Boundary Router (ASBR).

Each area is assigned a unique identifier *area-id*. An area with *area-id* equal to zero is called a backbone of OSPF system. OSPF backbone area always includes all ABR. Backbone area is responsible for routing information distribution between other (non-backbone) areas. Backbone area should be contiguous but it does not always imply a physical adjacency - backbone connections can be organized using virtual connections.

4.7.8.1 ABR models

OSPF router supports four models of ABR:

1. **cisco** - a router will be considered as ABR if it has several configured links to the networks in different areas one of which is a backbone area. Moreover, the link to the backbone area should be active (working).
2. **ibm** - identical to cisco model but in this case a backbone area link may not be active
3. **standard** - a router has several active links to different areas
4. **shortcut** - identical to standard but in this model a router is allowed to use a topology of connected areas without involving a backbone area for inter-area connections

Details on **cisco** and **ibm** models differences can be found in RFC3509. A *shortcut* model allows ABR to create routes between areas based on the topology of the areas connected to this router but not using a backbone area in case if non-backbone route will be "cheaper"

ABR model is selected using the following command in *config-router* mode:

```
abr-type (cisco|ibm|shortcut|standard)
```

If you want to use "shortcut" routes (non-backbone) for inter-area routes, you can use the following command in *config-router* mode:

```
area (A.B.C.D|<0-4294967295>) shortcut
   (default|enable|disable)
```

Three models define a usage of a specified area for routes shortcutting in shortcut mode:

- **Default** - this area will be used for shortcutting only if ABR does not have a link to the backbone area or this link was lost
- **Enable** - the area will be used for shortcutting every time the route that goes through it is cheaper
- **Disable** - this area is never used by ABR for routes shortcutting

4.7.8.2 Stub areas

Some of the areas may be defined as stub areas. It is used for the area which has either a single ABR or several ABR but route selection does not depend on external destination address. The information about external link (to OSPF system) is not sent to stub areas by ABR. Instead, ABR advertises a default gateway to the stub area with a route coming through this ABR.

The area can be configured as a stub area using the command in config-router command:

```
area (A.B.C.D|<0-4294967295>) stub [no-summary]
```

no-summary option is specified if it is not necessary to advertise a summary ads of other area's links to this area.

4.7.8.3 Backbone coherence. Virtual links

In general, OSPF protocol requires a backbone area (area 0) to be coherent and fully connected. I.e. any backbone area router must have a route to any other backbone area router. Moreover, every ABR must have a link to backbone area. However, it is not always possible to have a physical link to the backbone area. In this case between two ABR (one of them has a link to the backbone area) in the area (not stub area) a virtual link is organized. This can be done using the following command in config-router mode:

```
area (A.B.C.D|<0-4294967295>) virtual-link A.B.C.D
```

where:

- **(A.B.C.D|<0-4294967295>)** - area identifier through which a virtual link goes
- **A.B.C.D** - ABR router-id with which a virtual link is established. Virtual link must be configured on both routers. For example:

Router 192.168.152.45:

```
OSPF> configure
OSPF(config)# router
OSPF(config-router)# area 0.0.0.1 virtual-link 192.168.78.12
```

Router 192.168.78.12:

```
OSPF> configure
OSPF(config)# router
OSPF(config-router)# area 0.0.0.1 virtual-link 192.168.152.45
```

Formally, the virtual link looks like a point-to-point network connecting two ABR from one area one of which there is a link to backbone area. This pseudo-network is considered to belong to the backbone area.

4.7.8.4 Link-to-area information filtering

Summary information about area's links which is advertised by ABR through backbone to other area (export) can be filtered. Moreover, the information from ABR (that came from other areas) can also be filtered (import).

Filters are configured in *config-router* mode:

```
area (A.B.C.D|<0-4294967295>) export-list NAME

area (A.B.C.D|<0-4294967295>) filter-list prefix WORD
   (in|out)

area (A.B.C.D|<0-4294967295>) import-list NAME
```

where

- **NAME** - name of a filtering list (access-list),
- **WORD (in|out)** - name of a filtering prefix-list with direction specification (in - import, out - export). Filters can be configured for all areas to which ABR is connected except for the backbone area.

4.7.8.5 Links aggregation. Advertising suppression

For every area to which OSPF router is connected there is a list of address ranges for link aggregation before sending a summary LSA to the backbone area. Aggregated links are checked to belong to one of the address ranges. If several links belong to one address range, ABR makes an advertisement to the backbone (or to other areas) of only one single link with destination equal to the address range and a metric equal to the maximal metric of all the links or equal to the specified for this range value. It is possible to announce that some range is a blocking one, and then advertising of the links which belong to this range will be blocked. When advertising an aggregated backbone link to other (non-backbone) areas, the aggregation will not be performed if the area to which backbone links are advertised is a transit area (it has virtual links).

The list of addresses ranges for the area consists of the records that consist of the following fields:

- Range of addresses (R)
- Flag of advertisement suppression (not-advertise)
- The metric of an aggregated link (C)

- Advertised link (Rs)

If non-advertise flag is not specified, C and Rs parameters can be configured. If a destination for one or more links belongs to R, the router will advertise one link with R destination (or Rs, if specified) and with metric that is a maximal metric of the links (or C, if specified).

For addresses ranges there are several commands in *config-router* mode.

The command creates a range R and one can specify a "non-advertise" flag:

```
area (A.B.C.D|<0-4294967295>) range A.B.C.D/M [not-advertise]
```

The command creates a range R and configures a metric for an aggregated link C:

```
area (A.B.C.D|<0-4294967295>) range A.B.C.D/M [cost
   <0-16777215>]
```

The command creates a range and possibly creates a Rs destination instead of R:

```
area (A.B.C.D|<0-4294967295>) range A.B.C.D/M substitute
   A.B.C.D/M
```

4.7.8.6 Adjacency. Neighbors

When two or more routers have links to the same network these routers become neighbors in order to synchronize their Link-State Database. Moreover, a network with more than one router connected to it is a transit network; and, if this network is not point-to-point network, it is an active OSPF object (it can advertise its links to the routers). A special designated router makes a LSA. A designated router is selected from a number of active OSPF routers connected to the network based on their priorities, identifiers and IP-addresses of network interfaces by means of which they are connected to the network. The router uses special protocols which parameters should be identical for the neighbors. These parameters are:

- hello-interval
- dead-interval

By default, hello-interval equals 10 seconds; dead-interval equals 40 seconds. To modify these parameters for any network interface, use the following commands in *config-if* mode:

```
dead-interval <1-65535> [A.B.C.D]

hello-interval <1-65535> [A.B.C.D]
```

The value of the parameter is specified in seconds. "**IP-address**" defines IP-address of a specific link, if you need to configure this particular link (optional parameter). If this IP-address is not specified, the parameter will be applied to the network interface. Note that in order to creating adjacency relationship between two routers these parameters should be equal.

One of the routers connected to the network is automatically selected to be a designated router (DR) judging by three parameters. If a link priority is specified for the router it acts as a major criterion for DR selection. If priority is not set, only router-id and IP-address affect the selection.

To set up router's priority for the interface one can using the following command in config-if mode:

```
priority <0-255> [A.B.C.D]
```

Alike previously mentioned parameters, the priority can be set either to every link on the interface individually or to the interface as a whole. The bigger the priority the more chances this router has to become a designated router for this network. If this parameter is set to zero, this router will never be selected as a designated router.

OSPF protocol requires that Link-State databases of one area routers should be identical. To do that routers exchange LSA information. In particular, transit networks are used. In order to minimize network traffic, routers exchange their LSA not directly with each other but using DR and Backup DR (BDR). BDR is used for backing up DR in case of DR failure. BDR selection rules are identical to DR selection rules. While Link-state database synchronization the routers exchange database descriptions using master-slave relationship and broadcast IP-packets. Each packet reception should be acknowledged. If acknowledge is not received, initiating party makes a series of retransmits. OSPF administrator can control periodicity of these retransmits for each interface and/or interface's links in config-if mode:

```
retransmit-interval <3-65535>  [A.B.C.D]
```

This retransmit interval is specified in seconds.

LSA exchange is performed in the following cases:

- start of the router or its connection to the network (link creation) after selecting a network designated router
- after receiving LSA from any other area's router
- periodically after old database information expiration

After receiving updated information about links changes, the router initiates its link-state database synchronization with its neighbors, if it's a DR. This process does not start right after new information receipt but after a period of time assuming that some more data may come. This is made in order to avoid network "storms". The time for the delay can be configured for every interface/link in config-if mode:

```
transmit-delay <1-65535> [A.B.C.D]
```

Moreover, the router automatically updates link-state information with its neighbors. Only obsolete information is updated which age has exceeded a specific threshold. By default, this threshold equals 1800 seconds (half an hour) and it can be changed using the following command in config-router mode:

```
refresh timer <10-1800>
```

The parameter is specified for the OSPF router in general.

Virtual link is a point-to-point transit network. In this network a neighboring relationship is also established between two routers. For virtual links there are similar parameters for neighboring relationship establishment. These parameters are configured in *config-router* mode:

```
area (A.B.C.D|<0-4294967295>) virtual-link A.B.C.D
   (hello-interval|<1-65535>

   retransmit-interval|

   transmit-delay|

   dead-interval)
```

4.7.9 Authentication. Identity Check

In order to prevent an unauthorized connection of the devices to OSPF system, the system has an identity check for protocol's packets. Currently the device has two different options for identity check (authentication):

- **Password authentication**. All packets sent to the network should have a corresponding value in a 64-bit OSPF authentication header data field. The value is a 64-bit password (not encrypted). Simple password authentication is vulnerable for passive attacks (sniffing) because broadcasting is used and the packet has a password in an explicit form.

- **Cryptographic authentication**. For each OSPF packet a key is used while generation and check of message-digest signatures which are added to the end of OSPF packet. Digital signature is built based on MD5 algorithm. Digital signature is based on one-way function using OSPF packet and a secret key.

As a secret key is never send over the network in a clear form, this gives a protection from passive attacks.

By default, the device does not have any authentication (null-authentication).

Authentication can be configured individually for each interface's link (or for the interface including virtual link) and/or individually for every area to which the router is connected.

For interfaces authentication parameters are configured using the following commands in *config-if* mode:

1 Password authentication:

```
authentication-key AUTH_KEY [A.B.C.D]
```

where **AUTH_KEY** - password, **IP-address** is an optional parameter when individual link configuration is required.

2 Cryptographic authentication:

```
message-digest-key <1-255> md5 KEY [A.B.C.D]
```

where **KEY** - secret MD5 key, **IP-address** of the link in case of individual link configuration. <1-255> - a serial number of a secret key. Thus for the current link or interface one can configure up to 255 secret keys. For packets sending the router will use the latter keys among configured. For packets receiving the router will use the key with the same serial number as was used by the sender.

By setting up authentication parameters, one can turn it on by the config-if mode commands:

[(null|message-digest)]	**[A.B.C.D]**
Authentication type. null - no authentication (obligatory authentication suppression). With no parameter at all, a simple password authentication is turned on.	IP-address of interface's link

Virtual links authentication is configured in the same way in config-router mode:

Parameters:

```
area (A.B.C.D|<0-4294967295>) virtual-link A.B.C.D
   authentication-key AUTH_KEY
```

```
area (A.B.C.D|<0-4294967295>) virtual-link A.B.C.D
   message-digest-key <1-255> md5 KEY
```

Type of authentication settings:

```
area (A.B.C.D|<0-4294967295>) virtual-link A.B.C.D
   (authentication|) (message-digest|null)
```

Authentication type can be specified for the whole area to which a network belongs and a link by means of which OSPF packets are received. If authentication is turned on for both interface and the area, the interface authentication type will be used. In order to configure authentication type if it was disabled for interface (link) one can configure authentication type for the area using a command in *config-router* mode:

```
area (A.B.C.D|<0-4294967295>) authentication [message-digest]
```

If **message-digest** option is not specified, simple password authentication will be enabled for the area.

As was mentioned before, area authentication type is applied only if interface's authentication was totally disabled. However, interface's authentication parameters will be used.

To turn on area authentication, use the following command in config-router mode:

```
no area (A.B.C.D|<0-4294967295>) authentication
```

4.7.10 Router Running Configuration View

To review current running configuration of the router there are several commands in the basic mode of CS. In any mode of CS there is a command:

```
show running-config
```

This command shows a current router's configuration.

The configuration is shown as list of commands which brought the router to its current state.

Example:

```
OSPF> show running-config


Current configuration:
interface eth0
interface eth1
interface lo0
interface null0
interface tun0
```

```
 network point-to-point
router
 router-id 195.38.45.107
 network 1.1.1.1/32 area 0.0.0.0
 network 4.7.8.0/24 area 0.0.0.1
 network 192.168.15.1/24 area 0.0.0.1
 network 195.38.45.107/26 area 0.0.0.0
 area 0.0.0.1 virtual-link 192.168.151.10
end
OSPF>
```

4.7.10.1 Neighbor

```
show neighbor [A.B.C.D] [detail]
```

As a parameter one can specify IP-address of a network interface (link), which state and neighbor is to be shown. If this parameter is not specified the command shows a summary information for all interfaces.

Example:

```
OSPF> show neighbor


Neighbor ID     Pri   State          Dead Time   Address
   Interface
9.1.1.8           1   Full/DROther    00:00:32    1.1.1.2
   tun0:1.1.1.1
OSPF>
```

Table columns:

- *Neighbor ID* - neighbor router-id
- *Pri* - priority

- *State* - current state/status. This parameter may be of the following value:
  - **Init**. This state means that a Hello packet was recently received from a neighbor with whom a 2-way connection is not yet established.
  - **2-Way**. A two-way connection is established between two routers. Starting from here an adjacency relationship is initiated.
  - **ExStart**. The first step in adjacency relationship establishing which sets up master/slave relations.
  - **Exchange**. In this state a router fully describes its link-state database by sending packets to its neighbor.
  - **Loading**. A state in which link-state database synchronization happens, i.e. a request for new information is sent to the neighbor.
  - **Full**. This state means that neighboring relationship is established and list-state database is synchronized.
  - Current status may be of the following values:
    - **DR** - the router is selected to be a designated router.
    - **Backup** - the router is selected as a backup designated router.
    - **DROther** - the router is neither DR nor BDR
- *Dead Time* - the time left for neighbor acknowledgement packet.
- *Address* - neighbor's IP-address
- *Interface* - interface (link) through which information with neighbor is exchanged.

If option **detail** is specified in the command, the information on neighbors is shown in the detailed way.

4.7.10.2 Database

```
show database
```

The command shows a summary table with a database contents (LSA).

show database	**(asbr-summary|external|network|router|summary)**	**[A.B.C.D]**	**[adv-router A.B.C.D]**
	Type of link advertisement for review	Link destination which advertisements are to be reviewed	Router-id which link advertisements are to be reviewed

For example, a database has to be viewed for the link which were announced by transit network, and the advertising routers was 192.168.45.107:

```
OSPF> show database network adv-router 192.168.45.107

       OSPF Router with ID (192.168.151.10)

                Net Link States (Area 0.0.0.0)

                Net Link States (Area 0.0.0.1)

  LS age: 473

  Options: 0x2  : *|-|-|-|-|-|E|*

  LS Flags: 0x6

  LS Type: network-LSA

  Link State ID: 192.168.15.1 (address of Designated Router)

  Advertising Router: 192.168.45.107

  LS Seq Number: 80000001

  Checksum: 0x9148

  Length: 32

  Network Mask: /24

        Attached Router: 192.168.45.107

        Attached Router: 192.168.151.1

                Net Link States (Area 0.0.0.2)

OSPF>
```

4.7.10.3 Filtration objects

```
show access-list
   [(<1-99>|<100-199>|<1300-1999>|<2000-2699>|WORD)]
```

This command is used to print access lists contents. If list identifier is not specified, all lists are printed. For example:

```
OSPF> show access-list
IP access list any_network
    permit any
IP access list net200
    permit 192.168.200.0/24
```

Similar commands are used for prefix-lists output:

```
show prefix-list
show prefix-list WORD
```

4.7.10.4 Routing table

```
show route
```

This command prints a routing table. For example:

```
OSPF> show route
============ OSPF network routing table ============
N IA 1.1.1.1/32            [3] area: 0.0.0.1
                           via 192.168.15.1, eth0
N IA 1.1.1.2/32            [2] area: 0.0.0.1
                           via 192.168.15.1, eth0
N    4.7.8.0/24            [2] area: 0.0.0.1
                           via 192.168.15.1, eth0
N IA 9.1.1.0/24            [12] area: 0.0.0.1
                           via 192.168.15.1, eth0
N IA 192.168.0.0/24        [3] area: 0.0.0.1
                           via 192.168.15.1, eth0
N    192.168.15.0/24       [1] area: 0.0.0.1
                           directly attached to eth0
N IA 192.168.80.0/24       [12] area: 0.0.0.1
                           via 192.168.15.1, eth0
N    192.168.151.0/24      [1] area: 0.0.0.1
```

```
                                directly attached to eth0
N IA 192.168.152.0/24           [2] area: 0.0.0.1
                                via 192.168.151.10, eth0
N IA 195.38.45.64/26            [2] area: 0.0.0.1
                                via 192.168.15.1, eth0
============ OSPF router routing table =============
R    192.168.151.10             [1] area: 0.0.0.1, ABR, ASBR
                                via 192.168.151.10, eth0
R    195.38.45.107              [1] area: 0.0.0.1, ABR
                                via 192.168.15.1, eth0

============ OSPF external routing table ===========
N E2 192.168.200.0/24           [1/7] tag: 0
                                via 192.168.151.10, eth0

OSPF>
```

This table consists of three parts:

1. **OSPF network routing table**. This section includes a list of acquired routers for all accessible networks (or aggregated area ranges) of OSPF system. **IA** flag means that route destination is in the area to which the router is not connected, i.e. it's an inter-area path. In square brackets a summary metric for all links through which a path lies to this network is specified. **via** prefix defines a router-gateway, i.e. the first router on the way to the destination (next hop).
2. **OSPF router routing table**.
3. **OSPF external routing table**. E2 flag points to the external link metric type (E1 - metric type 1, E2 - metric type 2). External link metric is printed in the format of <metric of the router which advertised the link>/<link metric>.

4.7.10.5 Interfaces information

```
show interface [INTERFACE]
```

This command prints the information on network interfaces including virtual links states. If interface name is not specified, all interfaces information will be printed. For example:

```
OSPF> show interface
VLINK0 is up
  Internet Address 192.168.151.10/24, Area 0.0.0.0
  Router ID 192.168.151.10, Network Type VIRTUALLINK, Cost: 2
  Transmit Delay is 1 sec, State Point-To-Point, Priority 1
  No designated router on this network
  No backup designated router on this network
  Timer intervals configured, Hello 10, Dead 40, Wait 40,
   Retransmit 5
    Hello due in 00:00:08
  Neighbor Count is 1, Adjacent neighbor count is 1
eth0 is up
  Internet Address 192.168.151.10/24, Area 0.0.0.1
  Router ID 192.168.151.10, Network Type BROADCAST, Cost: 1
  Transmit Delay is 1 sec, State DR, Priority 1
  Designated Router (ID) 192.168.151.10, Interface Address
   192.168.151.10
  Backup Designated Router (ID) 192.168.151.1, Interface
   Address 192.168.151.1
  Timer intervals configured, Hello 10, Dead 40, Wait 40,
   Retransmit 5
    Hello due in 00:00:05
  Neighbor Count is 1, Adjacent neighbor count is 1
  Internet Address 192.168.152.1/24, Area 0.0.0.2
  Router ID 192.168.151.10, Network Type BROADCAST, Cost: 1
  Transmit Delay is 1 sec, State DR, Priority 1
  Designated Router (ID) 192.168.151.10, Interface Address
   192.168.152.1
  No backup designated router on this network
```

```
  Timer intervals configured, Hello 10, Dead 40, Wait 40,
   Retransmit 5

    Hello due in 00:00:03

  Neighbor Count is 0, Adjacent neighbor count is 0

lo0 is up

  OSPF not enabled on this interface

null0 is down

  OSPF not enabled on this interface

Rf5.0 is up

  OSPF>
```

4.8 Netstat Command (Network Statistics)

Display the network statistics

Syntax:

```
netstat -r

netstat -i
```

Description:

Displays the contents of different system data pertained to network parameters.

"**-r**" parameter displays system routing tables:

```
Routing tables
Destination       Gateway            Flags     Refs     Use  Interface
default           1.0.0.1            UG           0       0  eth0
1.0.0.0/8         link#2             UC           0       0  eth0
1.0.0.1           00:16:76:d3:bf:3e  UHL          1       0  eth0
1.0.12.0/24       link#3             UC           0       0  eth1
1.0.200.1         00:04:35:00:1d:10  UHL          1     176  eth0
8.1.2.0/24        link#2             UC           0       0  eth0
8.1.2.9           00:15:58:4a:d3:e9  UHL          1     445  eth0
127.0.0.1         127.0.0.1          UH           0       0  lo0
224.0.0.0/8       127.0.0.1          UGS          0       0  lo0
```

Figure 4-6: Netstat Output

Flags for specific routes have the following meaning:

- **U** - this routing table element is currently active;
- **H** - this route leads to a host. If this flag is not set, the route goes to a network;
- **D** - the route has been created using the **icmp redirect** protocol;
- **M** - the route has been modified using the **icmp redirect** protocol;
- **G** - the route is connected to a host. If this flag is not set, it is considered that the route destination is directly connected;
- **S** - static route, set by the operator using a **route add** command;
- **1** - pseudostatic route, set as a result of a **rip static** command;
- **L** - the route points to a directly connected host (for such a route an APR request may be performed);

- **C** - when using this route, more specific routes may be created (e.g. using the **L** flag).

"**-i**" parameter displays the information on each network interface in the system:

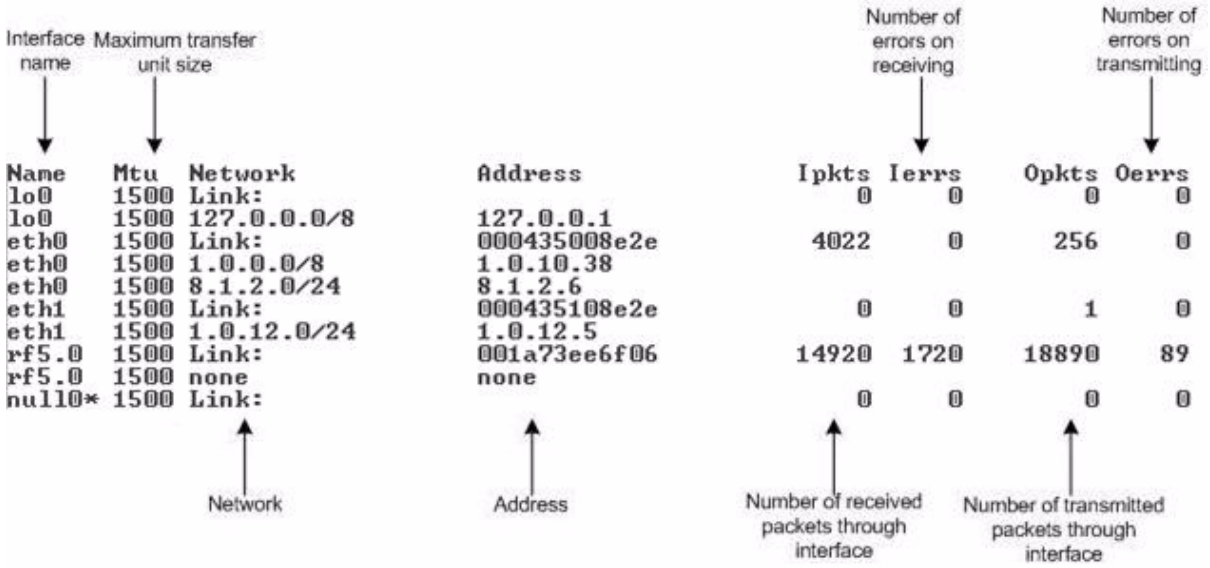

Figure 4-7: Netstat -i Output

4.9 Ipfw Command (IP Firewall)

4.9.1 General Description

IP Firewall is a mechanism of filtering packets crossing an IP network node, according to different criteria. System administrator may define a set of incoming filters (**add**) and a set of outgoing filters (**addout**). The incoming filters determine which packets may be accepted by the node. The outgoing filters determine which packets may be forwarded by the node as a result of routing.

Each filter describes a class of packets and defines how these packets should be processed (reject and log, accept, accept and log).

Packets can be filtered based on the following criteria:

- Protocol (IP, TCP, UDP, ICMP, ARP);
- Source address and/or destination address (and port numbers for TCP and UDP);
- The network interface it arrived on;
- Whether the packet is a TCP/IP connection request (a packet attempting to initiate a TCP/IP session) or not;
- Whether the packet is a head, tail or intermediate IP fragment;
- Whether the packet has certain IP options defined or not;
- The MAC address of the destination station or of the source station.

Below figure illustrates how packets are processed by the filtering mechanism of the device.

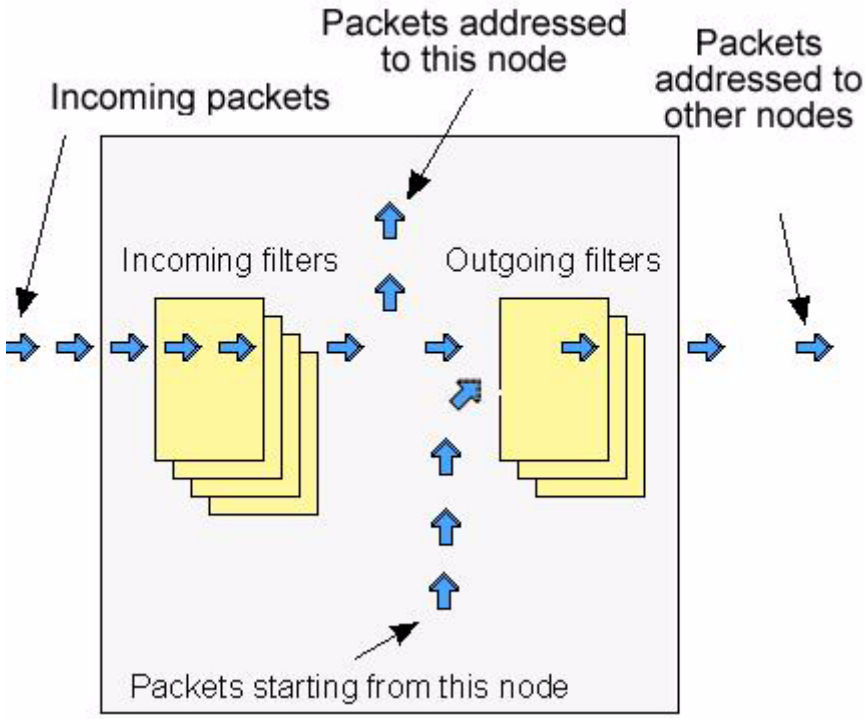

Figure 4-8: IPFW

There are two classes (sets) of filters - prohibiting (**reject**) and permitting (**accept**).

Furthermore, a filter may be applied to all inbound packets or only to packets arriving via a specific interface.

Each received packet is checked against all filters in the order they are put in the set.

The first filter that matches the received packet determines how the packet will be treated. If the filter is an accept filter, the packet is accepted, otherwise it is rejected. If the packet matches no filter in the set, or if the set is empty, the packet is accepted.

CAUTION

The rejected packet will be discarded without notification to the sender.

Filters are defined using the **ipfw** command. For example, a command

```
ipfw add reject all from 192.168.5.3 to 192.168.11.7
```

adds to the set of incoming filters a reject filter which will discard all packets with source address 192.168.5.3 and destination address 192.168.11.7.

For better understanding of how filtering mechanism works, it is necessary to read how filters are defined and how filters are used.

Syntax:

```
list

show | reset

flush

quiet | -quiet

del num

mov num1 num2

add[out] [NUM] [IFNAME] rules...


rules: [{setpri|addpri}=N|-1|-2] accept|reject|rpfilter|pass
   [log]
   [vlan=N] [dot1p=N] [swg=N] [ether=X] [dscp=N|tos=N]
   -f "pcap filter expression"
   |
   PROTO from [not] ADDR [PORTs] to [not] ADDR [PORTs]


   PROTO: [all] | tcp | udp | icmp | arp | proto NUMBER
   ADDR: IP | $LOCAL | $ROUTE | $ACL | mac {x:x:x:x:x:x}
   PORTS: NUM[:NUM] [NUM] ...
```

Description:

```
ipfw show / reset
```

This command shows "ipfw" rules/resets "ipfw" rules counters.

```
ipfw list
```

The set of currently defined filters is displayed on the operator terminal.

```
ipfw flush
```

All currently defined filters in both the incoming and outgoing filter sets are removed. Filtering is disabled.

```
ipfw add [num] . . .

ipfw addout [num] . . .
```

These two commands are used to add a filter to the incoming and outgoing filter sets, respectively. The **add*** keyword is followed by a filter definition.

The optional **num** parameter may be used to explicitly specify the number of the new filter in the list. Execution of a command with this parameter implies automatic renumbering of the previously specified filters occupying higher positions in the list.

```
ipfw del num
```

Removes a filter from the appropriate list. The filter to be removed is specified by its number num which can be seen using the **ipfw list** command. The rules remaining in the list will be renumbered automatically.

```
ipfw mov num1 num2
```

Moves the filter **num1** into the **num2** position in the appropriate list. The rules between these two positions in the list will be renumbered automatically, namely: if **num1<num2**, then all numbers i such that **num1<i<num2** will be decremented by 1, and if **num1>num2**, then all i such that **num2<i<num1** are incremented by 1.

```
ipfw [-]quiet
```

The **ipfw** quiet command disables registration of rejected packets. Registration is enabled by default, and re-enabled by **ipfw -quiet** command.

4.9.2 Packet Filtering Rules

Hereafter we give detailed description of how packets are treated by packet filters. Every packet entering a device passes through a set of input filters (or blocking filters). Packets accepted by the input filter set are further processed by the IP layer of the device kernel. If the IP layer determines that the packet should go further and not landing here, it hands the packet to the set of outgoing filters (or forwarding filters).

Information on packets rejected by any filter is displayed on the operator's terminal, and the packets themselves are discarded without any notice to their sender.

A packet, "advancing through" a set of filters is checked by every filter in the set, from the first one till the end of the set, or until the first matching filter. The algorithm is as follows:

1 If the filter set is empty, the packet is accepted.

2 Otherwise, the first matching filter decides the packet's fate. If it is an accept filter, the packet is accepted. If it's a reject filter, the packet is rejected (discarded).

3 If no filter has been found that matches the packet, it is accepted.

The algorithm of applying any specific filter to a packet is as follows:

1 If the value in the **proto** field of the filter is not all, and the packet's protocol is different from that specified in the filter, then the filter is skipped (not applied) for this packet.

2 If the source address in the packet differs from that specified in the filter, then the filter is skipped (if the source address is specified in the filter with a mask, then the mask is applied to both addresses before comparing them).

3 If the destination address in the packet differs from that specified in the filter, then the filter is skipped (a mask, if any, is applied similarly to the previous step).

4 If the **ip_fragment** modifier is specified in the filter, but the packet is not an IP fragment, then the filter is skipped.

5 If the **ip_tail_fragment** modifier is specified, but the packet is either the first or the only fragment, then the filter is skipped.

6 If the **ip_head_fragment** modifier is specified, but the packet is not the first fragment of a fragmented IP packet, then the filter is skipped.

7 If the **tcp_connection** modifier is specified, but the packet is not the first or the only fragment of a TCP connection establishment TCP/IP packet, then the filter is skipped.

8 If the **ip_option** modifier is specified, but the packet has no options (with possible exception for NO-OP or EOL options), then the filter is skipped.

9 If the **ip_recroute_option** modifier is specified, but the packet has no related options, then the filter is skipped.

10 If the **ip_misc_option** modifier is specified, but the packet has no IP options (with possible exception for record-route, timestamp, NO-OP or EOL options), then the filter is skipped.

11 If the value in the **proto** field of the filter is **udp** or **tcp**, and the source address in the filter contains a port list, then, if the packet is neither the first nor the only fragment, or if the source port in the packet does not match any port specified in the filter, then the filter is skipped.

12 If the value in the **proto** field of the filter is **udp** or **tcp**, and the destination address in the filter contains a port list, then, if the packet is neither the first nor the only fragment, or if the destination port in the packet does not match any port specified in the filter, then the filter is skipped.

13 Otherwise, i.e. if none of the above conditions has caused skipping the filter, then the packet is treated in a way specified by the **disp** field of the filter.

Special filtering rules for ARP packets:

- ARP packets will always be permitted for those IP addresses and ranges of IP addresses that are mentioned in permitting (accept) filters, even if those filters are created for other types of packets.

4.9.3 Packet Filtering Rules Syntax

Syntax:

```
[{setpri|addpri}=N|-1|-2] accept|reject|rpfilter|pass [log]
   [vlan=N] [dot1p=N] [swg=N] [ether=X] [dscp=N|tos=N]
   -f "pcap filter expression"
   |
   PROTO from [not] ADDR [PORTs] to [not] ADDR [PORTs]

   PROTO: [all] | tcp | udp | icmp | arp | proto NUMBER
   ADDR: IP | $LOCAL | $ROUTE | $ACL | mac {x:x:x:x:x:x}
   PORTS: NUM[:NUM] [NUM] ...
```

Description:

Below is a description of the syntax rules for creating packet filters. Most attention is given to the syntax itself, but still filter usage questions are described either.

A generic form of the filter description is given above in the Syntax paragraph. Optional field **interface** defines the name of the network interface to which the filter is going to be applied. Interface name depends upon the device model and can be eth0 or rf5.0 for specifying Ethernet interface or radio interface correspondingly. If th? interface parameter is set the filter will be applied only to those packets which are received or transmitted through this interface.

Setpri/addpri parameters allows to set/increase priority for a packet when a packet is treated by the filter. "**Setpri**" parameter is used to change a priority to the value specified in the command. When using "-1" value a package priority is dropped to the lowest priority. "**Addpri**" is used to change a priority only in case it is higher than the previous one (Note: the smaller is the value the higher is the priority). So you can only increase priority using "**addpri**" parameter.

Disp field (abbreviated from disposition) sets an action which is going to be held in case of this filter operation. Possible values are **accept** or **reject**. If **accept** value is set the packet will go through the filter. Using **reject** value means that the packet will be filtered. After the action value one can set an optional parameter log (**accept log** or **reject log**) - this will lead to the system log update in case of the filter operation.

Module "**ipfw**" added with filter "**rpfilter**" (reverse path filter). This filter ensures that the sender of the package is accessible via the interface through which package it received in the system. If the filter fails, the packet processing continues, if not fails the packet is destroyed. This filter can be inserted into the list of rules first:

```
ipfw add rpfilter all from 0/0 to 0/0
```

One more possible value for **disp** field is "**pass**". This value allows a packet to pass a rule executing the related actions of this rule and continue with other rules in the list.

Example:

```
ipfw add pass log tcp from 0/0 to 0/0
```

When a packet will face this rule it will continue moving further with other rules. Information about the packet will be logged.

Parameters **[vlan=N] [dot1p=N] [swg=N] [ether=X] [dscp=N|tos=N]** are classifiers that allows analyzing VLAN ID, 802.1p priority, switch group number (SWitchGroup), packet type (EtherType) and also **ip_tos** field for having DSCP label value or IP precedence.

Proto field sets some particular IP-protocol, which is used for the filter. Possible values: **tcp, udp, icmp, arp, all** or a numeric value of the protocol.

Optional field **modifiers** can be used to set up some additional packet parameters which are going to be described below in this document.

Mandatory key word **from** separates **proto** and **modifiers** fields from the destination address (endpoint). Key word **to** separates source address from destination address.

Endpoint defines either source address or destination address. The exact syntax of endpoint fields depends upon **proto** field value. If **proto** has a value of either **all** or **icmp** than endpoint contains the address information. If **proto** is set as **udp** or **tcp** than endpoint contains the address information and an optional ports list.

Address information is an IP-address with a mask (optional). IP-address should be set in a traditional numeric format (nn.nn.nn.nn). An optional mask can be set either as mask length in bits or as a numeric value in nnn.nnn.nnn.nnn format. Possible formats for address information are the following:

```
nn.nn.nn.nn

nn.nn.nn.nn:xxx.xxx.xxx.xxx

nn.nn.nn.nn/NN
```

Using semicolon means that the mask is set in a numeric address format. Slash symbol means that mask is set as a length in bit (number of first bits which are set as "1", others are set as "0").

Example:

192.168.9.0/24 sets the network address 192.168.9.0 with 24 bits mask length.

Second option: 192.168.9.0:255.255.255.0.

"0/0" means all possible IP-addresses.

If you need to create a filter which is applied to several network addresses or groups, it is more convenient to group all those addresses in one corresponding access list and specify the list name as an IP-address (**$ACLRULE**)

There are several predefined dynamic **ACL** lists which cannot be built in any other way.

$LOCAL list includes all local addresses owned by the device. This list can be used for a convenient filter description which allow (or restrict) the access to the device.

```
ipfw add accept all from 0/0 to $LOCAL
```

$ROUTE list contains system routes table excluding default route. When an address matches this list it means that this address has some specific route and default route will not be used in this case.

```
ipfw add reject all from 0/0 to not $ROUTE
```

For the interfaces which have physical MAC-addresses in Ethernet standard, it is possible to use a value of MAC-address with a key word **mac**. At that for the

incoming filters one can set only the MAC-address of the source, and for outgoing - only the MAC-address of the destination.

After **from** and **to** key words one can use a negative prefix **not**. Its action will spread only on the corresponding address (addresses) but will not influence the ports if they are used in the command.

Example:

```
ipfw add reject all from mac 0012345678 to 0/0
ipfw addout reject all from 0/0 to mac 0012345678
ipfw add rf1 reject all from mac $ACL to 0/0
ipfw add reject all from 0/0 to not 1.1.1.0/24
```

Ports list is set as a simple enumeration of ports separated by space bars.

The first element in the list can be a port couple separated by a semicolon. These ports will specify a port values range (from the smallest to the biggest inclusively).

One can specify up to 10 ports in the list.

The packets which are not a first fragment of the fragmented IP-packets are not checked to fulfill the port number restrictions (as a port number is specified only in the first fragment). If the first fragment is filtered the rest of the fragments will be rejected by the target machine IP-protocol.

Modifiers field is used for the additional packet characteristics which can be considered by the filter.

Possible values:

- **tcp_connection**

The filter is referred only to the packets of an establishing a TCP-connection. **connection** is synonym of tcp_connection. Technically, a packet for requesting a connection has a TCP header with SYN flag set and ACK flag cleared.

- **ip_fragment**

The filter refers only to fragmented packets. Technically, either offset field in the packet has non-zero value or a more fragments bit is set.

- **ip_head_fragment**

The filter is applied only to the first fragment of the fragmented packet. Technically an offset field in the packets has non-zero value or a more fragments bit is set.

- **ip_tail_fragment**

The filter is applied to all packet's fragments excluding the first one. Offset field has non-zero value. More fragments field value is of no importance.

- **ip_option**

The filter is applied to the IP-packets which have any IP-options set (excluding NO-OP option)

- **ip_recroute_option**

The filter is applied only to those IP-packets which have either record-route or timestampIP options set without any other options. These options can be set by violators to build your network map. No other threat is possible here.

- **ip_misc_option**

This filter is applied only to the packets which have one or more IP-options but record-route, timestempIP or NO-OP. Many of IP-options of MISC group are used by the violators to avoid filters in order to enter the network.

There are several additional rules for the modifiers field:

1. **tcp_connection** value can be used only when the proto field has tcp value
2. If more than one option among **ip_fragment**, **ip_head_fragment** or **ip_tail_fragment** is used, than the latter ones will cancel the action the former ones.
3. If more than one option among **ip_option**, **ip_recroute_option** or **ip_misc_option** is used, than the latter ones will cancel the action the former ones. The packet must fulfill all options set, otherwise it will go through the filter.

Parameter **-f** allows using "pcap" filters.

Example:

```
ipfw add reject -f "icmp and host (1.1.1.1 or 1.1.1.5)"
```

4.9.4 Examples of Packets Filtering

Hereafter some examples are given of how to use the **ipfw** command in different cases.

Simple examples:

Our first example will be a filter prohibiting passage of any packet from some "unreliable" address 1.1.1.1 to the address 2.2.2.2:

```
ipfw add reject all from 1.1.1.1 to 2.2.2.2
```

As enemies often attack in unite front, let us now bar the way to all packets from the whole hostile network:

```
ipfw add reject all from 1.1.1.0/24 to 2.2.2.2
```

Here **24** after the slash means the mask length in number of bits. The mask length of 24 corresponds to a C class network with 256 different node addresses. Using a colon sign ("**:**"), the same command may be equally expressed as follows:

```
ipfw add reject all from 1.1.1.1:255.255.255.0 to 2.2.2.2
```

We can go even further, stopping all packets sent from the enemy network to any address (provided of course that they pass through our device):

```
ipfw add reject all from 1.1.1.0/24 to 0/0
```

Filtering by port numbers

Now suppose that we want to authorize everybody to address an smtp service (mail agent) at the host with IP address 192.5.42.1. It may be done with the following command:

```
ipfw add accept tcp from 0/0 to 192.5.42.1 25
```

The **tcp** keyword means that the filter will be applied to TCP packets only. The IP-address of the mail host machine is followed by the port number 25, corresponding to the SMTP service.

You can use a port list to specify several ports in the same command. The first element in a list may be an interval of port numbers, specified by its lowest and highest values separated by a colon. For example, the following command

```
ipfw add accept tcp from 0/0 to 1.1.1.1 900:5000 25 113
```

will authorize passage of tcp packets sent to the IP address 1.1.1.1, if the destination port number is within the 900 to 5000 interval (including both extreme values), or is equal to 25 (smtp) or 113 (ident).

All the subnetworks of the inner network, including the innerhost address, belong to the same network (or group of network). Suppose that we know for certain that there may not be any host in the outer network having an address within the inner network's address range. Therefore, any packet received from the rf5.0 interface of a device running ipfirewall, hence from the outer network, but having the source address within the inner network's address range, must be discarded. It is done by the following command:

```
ipfw add rf5.0 reject all from innerhost/16 to 0/0
```

Unlike the filters in the previous examples, this filter will be applied to packets arriving through the rf5.0 interface only. Packets arriving through any other interface will not be discarded (in this example the inner network is supposed to be of the B class).

As an additional measure it may be useful to reject packets having a source address from within the loopback network (**127.0.0.0**):

```
ipfw add rf5.0 reject all from 127.0.0.0/8 to 0/0
```

IP spoofing has been widely used in the Internet as an aggression method. For additional information, see CERT summary CS-95:01, and also summaries on the CERT WWW site.

It is important to consider that a malefactor may use IP spoofing for breaking in your network despite an obvious fact that he will never receive any reply. See e.g. CERT advisory CA-95:01.

IP-spoofing

In the previous examples, the source address was used a main and the only criteria for the address reliability checking. Unfortunately, there is a possibility to send the packets from an unreliable address, substituting the return address with that you rely on (this attack method is called IP spoofing). It is clear that the checking only of the source address is not enough. It is necessary to check the path of the packet or, which is more practical, to check the interface through which the packet was accepted.

A network example is shown below:

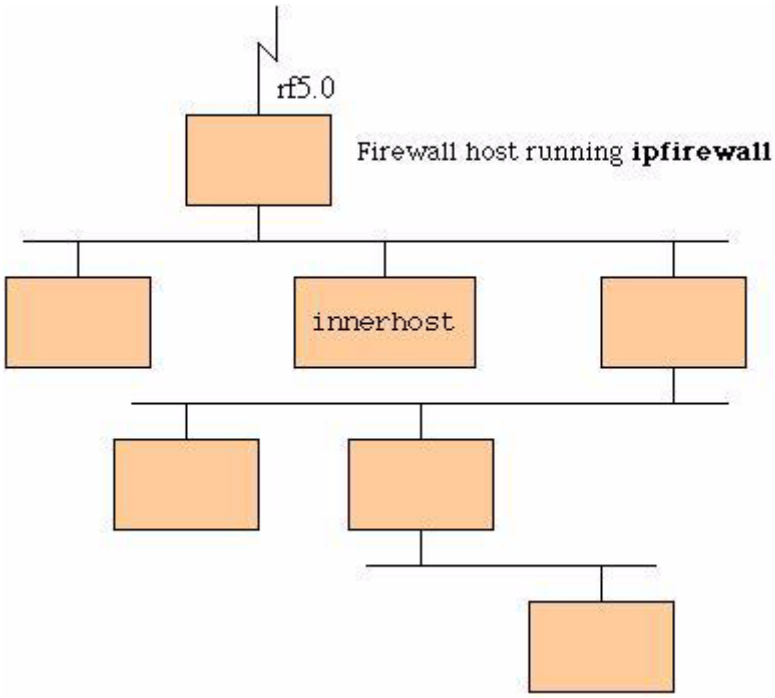

Figure 4-9: IP Spoofing

All subnets of an inner network, including a host address innerhost, are owned by the one network (or a network group). Let's imagine that outer network has no hosts which are within the range set up for the inner network. Therefore, all the packets that are accepted via rf5.0 interface of the device with firewall run on it and have the source address which is in the range of addresses of the inner network must be blocked. The following command can perform this action:

```
ipfw add rf5.0 reject all from innerhost/16 to 0/0
```

Compared to all previous examples this filter will be applied only to those packets which come through rf5.0 interface. Packets which come through any other interface ill not be blocked (in the example the inner network has addresses of the B class.

As an additional security measure it makes sense to block all packets with source address from the loopback network (127.0.0.0):

```
ipfw add rf5.0 reject all from 127.0.0.0/8 to 0/0
```

Filtering TCP connections

TCP/IP clients normally use port numbers between 900 and 5000 inclusive, leaving port numbers below 900 and above 5000 for servers. The following pair of filters will bar access to your servers for any outside clients (assuming that all

communications between your network and the external world pass through the **rf5.0** interface):

```
ipfw add rf5.0 accept tcp from 0/0 to 0/0 900:5000
ipfw add rf5.0 reject tcp from 0/0 to 0/0
```

The first of these filters accepts packets from external sources to ports from 900 to 5000 on the inner network hosts (normally assigned to internal clients). The second filter rejects all the rest.

Unfortunately, this is not enough. Some internal servers may be assigned port numbers within the 900 to 5000 range, and the above filter set would allow access to those servers for external clients. The problem consists in restricting external access to your servers having such port numbers while leaving them open for internal access. One of the possible solutions is to reject any attempt from an external client to establish a TCP connection with an internal server.

The **tcp_connection** modifier makes it possible to do:

ipfw add rf5.0 r**eject tcp_connection from 0/0 to 0/0 900:5000**

ipfw add rf5.0 accept tcp from 0/0 to 0/0 900:5000

ipfw add rf5.0 reject tcp from 0/0 to 0/0

The first filter in the above filter set wards off any attempt of TCP connection establishment from outside clients to your internal servers with port numbers 900 to 5000. The second filter authorizes any other incoming TCP packets aimed at port numbers within the same range; and the third filter rejects all other TCP packets.

This unreliable UDP protocol

Unlike the connection-oriented TCP protocol, the UDP protocol sends separate packets (datagrams). In this protocol every packet is transmitted independently from all others, and if there is a logical connection or session between a client and a server communicating through UDP, such connection or session exists between higher layer application entities only, and is invisible to UDP.

As all UDP packets are independent of each other, a UDP packet header bears no information on whether it is a client to server or a server to client packet (in fact, UDP users are all equal in rights; the terms client and server cannot be defined explicitly).

Therefore, the only recipe we can propose is to define as precisely as possible the range or set of those UDP port numbers which are allowed to communicate with the outer world.

A domain name server (**DNS**) is an example of a server using the UDP protocol (at port number 53). Assuming that your communications with the outer world all pass through the rf5.0 interface, the following filter set will provide for proper interaction between your internal DNS server and external DNS servers while rejecting any other UDP traffic:

```
ipfw add accept udp from 0/0 53 to 0/0 53
ipfw add rf5.0 reject udp from 0/0 to 0/0
```

Though it may appear an easy task, in reality it is very difficult to establish more open UDP access policy without creating large security holes. If, in particular, you decide to authorize your internal clients accessing external UDP servers, then you should take into account the following considerations (the list is far from exhaustive):

If you have NFS servers, these are traditionally using the UDP port 2049 (TCP versions of NFS servers also use the port number 2049, which may possibly be protected by the **tcp_connection** modifier - see examples above).

Some RPC portmapper implementations have grave security problems. Be very careful when authorizing external access to your internal portmapper resource (at TCP or UDP port 111).

Be also very careful in your choice of source and destination ports to authorize. You might be tempted to authorize external packets arriving from some port numbers you know. If you do, always remember that a malefactor can easily send any TCP/IP or UDP/IP packets with any combination of source ports and addresses replacing his own ones.

Some Microsoft LAN Manager services use UDP. As Microsoft has a visceral enmity against open secure protocols, and its own implementations have unprecedented number of bugs and errors, you should better exclude any possibility for potential malefactors to profit by this security hole:

```
ipfirewall add rf5.0 reject tcp from 0/0 to 0/0 135:139
ipfirewall add rf5.0 reject udp from 0/0 to 0/0 135:139
```

This subset of filters protects you quite securely from almost any possible attempt to break in your internal network having Windows NT/95/98 servers and/or workstations installed.

IP fragments

The **ip_fragment**, **ip_head_fragment** and **ip_tail_fragment** modifiers are intended for managing a flow of fragmented IP packets. For better understanding how you can use them, the following considerations should be taken into account:

- A filter verifying TCP or UDP port numbers never checks IP fragments except the first one in a sequence.

- If your filter accepts incoming IP fragments, a malefactor may use a "denial of service" attack, by flooding you with fragments having different source addresses, thus causing memory overflow on your device.

Therefore, to be protected from a possible "denial of service" attack, the only solution would be to prohibit reception of any fragmented packets:

```
ipfw add reject all ip_fragment from 0/0 to 0/0
```

This measure certainly strengthens your security; don't forget, however, that a malefactor still may use other methods of aggression, e.g. by simply pelting you with any packets or with useless e-mail messages.

Moreover, rejecting all incoming fragmented packets may hamper your normal work. Consider the following example. The maximum possible IP packet length is usually circa 1500 bytes; but it may be less or more on different network segments. Even those packets which have not been sent fragmented by their source, may have become fragmented somewhere on their way to destination, because they have encountered a network segment with more severe packet length limitation. Even the newest protocols for defining the maximum possible IP packet length along any given route are not always bringing guaranteed result, because IP packets from the same source are progressing independently through the network, and may take different routes. Therefore, fully prohibiting reception of fragmented packets may hinder (temporarily or permanently) normal operation of some applications communicating with some hosts.

If you decide to authorize incoming fragmented packets, then one of the first filters to apply could be

```
ipfw add accept all ip_tail_fragment from 0/0 to 0/0
```

The above filter accepts all incoming fragments except the first fragments (of their respective packets). Such an authorization is not harmful for your security (with the exception of a "denial of service" attack), because the first fragment of a packet, bearing the main information about the whole packet, will be already verified by some of the preceding filters. If the first fragment has been rejected by a filter, then all the remaining fragments, when received by the destination host in the absence of the first one, will be rejected there after some delay (normally fixed at 60 sec.).

Logging of packets

IP Firewall registers all rejected packets, writing appropriate message in the system log. Registering all accepted packets may be additionally requested by putting a **log** keyword:

```
ipfw add accept log icmp from 0/0 to 0/0
```

The above command will register all incoming ICMP packets.

CAUTION

A big number of logged packets may cause system log overflow (if you have redirected log messages to a remote workstation).

4.10 Loadm Command (Load Meter)

This is a tool to perform the channel load monitoring

Syntax:

```
loadm [-B] [-l] [-m][-w XX] interface
```

Description:

This command allows estimating the load of a system interfaces specified by **interface** parameter. By default, the information is displayed in one line and is updated every second; the load is measured in Kbit/s.

The following additional keys change default settings:

- **-B**: display values in thousand of bytes per second;
- **-l**: display information line by line;
- **-m**: display results in Megabits per second;
- **-w XX**: specifies time interval XX between updates.

Example:

```
loadm -l rf5.0
```

The output example is shown below.

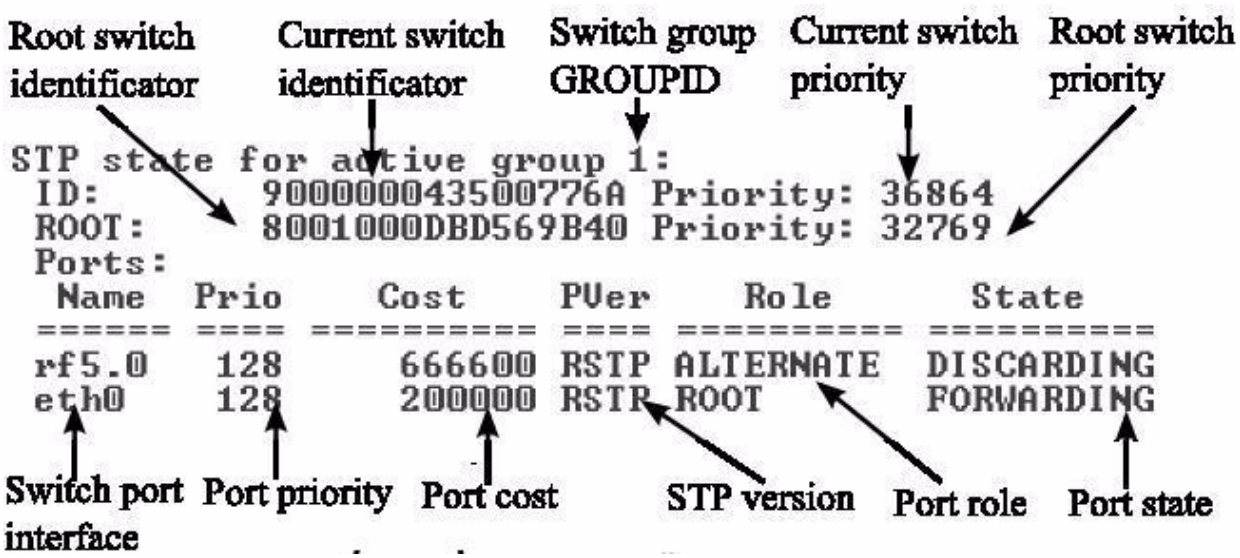

Figure 4-10: Loadm output

4.11 Bpf Command (Berkeley Packet Filter)

The command enables packet capturing mode (Berkeley Packet Filter)

Syntax:

```
bpf interface PARAMS
PARAMS are:  ADDR PORT [LEN] [-promisc] | - | stop
             -f "pcap filter expression"
```

Description:

The packet capturing mode, which is enabled by "**bpf interface ADDR PORT**" command and disabled by "**bpf interface -**" command, allows replicating entire information flow through any of the system interface and forwarding the replica to a remote workstation for subsequent analysis and check. The filter does not interfere with normal operation of the router.

Because of limited memory capacity and CPU speed, the device software is not capable itself of sorting and analyzing data flows. The bpf command helps to perform thorough analysis on any network workstation, even in real time.

Each packet of the data flow through the specified interface (together with its MAC header) is sent using the UDP protocol to a remote workstation at the specified address and port.

Parameters are as follows:

- **ADDR**: the IP address of the destination of the replicated data stream.
- **PORT**: the number of the port to which the replicated data stream should be sent.
- **[LEN]**: specifies a number of bytes from the beginning of the packet that will be send for analysis.
- **[-promisc]**: when enabled captures only those packets that are appointed to the given device. When disabled captures all the packets.
- **- | stop**: disables "bpf" command.
- **bpf -f** - allows to set pcap filter.

Example:

```
bpf rf5.0 10.11.12.13 8000
```

Enables packet capturing regime, sending all packets from the rf5.0 interface to a workstation at the address **10.11.12.13**.

```
bpf rf5.0 -
```

Disables packet capturing regime at the rf5.0 interface.

4.12 Snmpd Command (SNMP Daemon)

SNMP protocol version 1 and 3 daemon

Syntax:

```
snmpd user NAME (add|set) [pass PASSWORD] [sec[urity]
   (noAuthNoPriv|authNoPriv)] [acc[essRights]
   (readOnly|readWrite)] [cla[ss] (guest|admin)]

snmpd user NAME del[ete]

snmpd comm[unity] NAME

snmpd (v1disable|v1enable)

snmpd (start|stop)
```

Description:

This command enables/disables the SNMP (Simple Network Management Protocol) Version 1 and 3 daemon.

SNMP protocol support is an important feature of all communication devices because it allows the system administrator to use a uniform mechanism to manage the operation of a network as a whole and of every its component individually.

Although the first version of the SNMP protocol lacks security in the operation of the protocol itself, which hinders its use for network management, it is widely used to monitor and analyze network operation. MIB variables changing are turned off for the first version; it works only in read-only mode. **v1disable** option disables 1st version support completely and slightly fastens incoming SNMP-requests processing.

Now we have a support of SNMP-V3 with USM (User-based Security Model) and MD5 authentication excluding encryption. For access granting, a user with username, password and access rights (with or without authentication) is being created.

In "snmpd" command **accessRights** can be set to provide access management of the recourses. **ReadOnly|readWrite** parameters allow only reading or also changing some variables. **Class guest/admin** allow providing limited or full access to the variables.

The present implementation supports MIB II (Management Information Base, Version II) and MIB Enterprise and is very easy to configure.

Example:

```
snmpd comm secret
snmpd user john add pass mypassword security authNoPriv
snmpd on
```

4.13 Td Command (Telnet Daemon)

Telnet daemon management.

Syntax:

```
td enable | disable RemoteHOST

td start | stop | flush
```

Description:

Telnet daemon makes it possible to remotely configure and manage a device, and more generally to execute any operation system commands in the same way as it is done on a local operator workstation.

Telnet daemon starts automatically when the device is switched on.

To stop the daemon operation, a **td stop** command shall be executed; a **td start** command restarts the daemon.

By default, the daemon accepts **SNMP** connection establishment requests from any host in the network. After executing one or several **td enable RemoteHOST** commands, remote SNMP access becomes only possible from the explicitly specified IP-addresses (one host specified per each td enable command, up to 10 hosts enabled simultaneously).

To retire from a remote host a previously granted access authorization, a td disable command with its IP-address shall be executed.

Finally, a **td flush** command fully clears the current telnet daemon configuration.

Examples:

```
td enable 195.38.44.1

td enable 195.38.44.11

td start
```

4.14 Nat Command (Network Address Translation)

Network address translation according to RFC1631.

Syntax:

```
nat [arguments]


Arguments:
alias_address     (-a),
local_acl         (-acl)
maxlinks          (-ml)
reverse           (-re)
ignore_incoming   (-i)
same_ports        (-sp)
verbose           (-v)
stat              (-s)
 redirect_port     (-rpo)
redirect_proto    (-rpr)
redirect_address  (-ra)
proxy_rule        (-pr)
default_h323      (-dh)
h323_destination  (-hd)
proxy_only        (-po)
skinny_port       (-skp)
del               (-del)
enable            (ena)
 disable           (dis)
```

Description:

- **-a** - sets public address to use for aliasing (obsolete) argument:

x.x.x.x | 0.0.0.0

-acl $NAME [public_addr|dhcp IFNAME] [enable|disable|delete] - enables/disables or deletes a list of local networks and public address or dhcp on the specified interface.

- **-ml NUM** - sets maximal links number
- **-re [yes|no]** - enables operation in reverse mode
- **-i [yes|no]** - enables ignoring of unknown incoming connections
- **-sp [yes|no]** - tries to keep original port numbers for connections
- **-v [yes|no]** - enables verbose mode that dumps packet information to system log
- **-s** - enables NAT statistic
- **-rpo** - redirects a port (or several ports) for incoming traffic.
- **-rpr** - redirects packets of a given proto
- **-ra** - defines mapping between local and public addresses
- **-pr** - adds transparent proxying / destination NAT
- **-dh [yes|no]** - uses default H.323 ports for outgoing connections
- **-hd** - describes H.323 outgoing connection
- **-po [yes|no]** - sets "transparent proxy only" mode with no aliasing
- **-skp port** - sets the TCP port for the Skinny Station protocol
- **-del rule_number** - deletes nat rule
- **ena** - enables nat translation
- **dis** - disables nat translation

4.14.1 General Description

NAT allows solving to the certain extent the problem IPv4 address space exhausting. It means that several computers in the given LAN may connect to Internet via the same public IP address. NAT-module receives outgoing IP-packets, modifies sender's IP address to the public IP address and forwards it to Internet. Sender's IP address is modified in such a way that it is possible to identify the sender when IP packet received on the LAN incoming interface and to forward the IP packet to the initial sender. NAT-module is similar to **natd** and **libalias** from FreeBSD. Original manuals can help understand the subject better.

As its known (rfc1918), some part of IPv4 address space is reserved for using in so called private IP networks (private internets).

10.0.0.0 - 10.255.255.255 (10/8 prefix)

172.16.0.0 - 172.31.255.255 (172.16/12 prefix)

192.168.0.0 - 192.168.255.255 (192.168/16 prefix)

Internet backbone routing protocols do not advertise these addresses, which allows to use the same addresses in different Internet segments. These addresses are used by ISP's and enterprises to build internal transport environment and/or to connect small subscriber communities.

Perhaps, when connecting your LAN to Internet, ISP will suggest you to minimize the number of really existing IP-addresses in order to save its own address space. Common user needs very limited set of well-known services: WWW, FTP, ICQ, Telnet, SMTP, Games. This is quite accessible using private internets and NAT. Besides, there are dedicated proxy-servers for concrete services which fit better for this task. E.g. for HTTP and FTP it is better to use caching proxy server Squid.

If you decided to use IP-telephone based on H.323 standard, then it is better to use private internets. We have H.323 support module in our NAT version.

So, we have the following scenario: using private internets in your LAN and you have a limited number of public IP-address.

4.14.2 Commands Description

```
nat local_acl $NAME aliasIP
```

This command sets the real (public) IP-address which will be used for address translation. In order for the routing protocols to work normally, this address must be assigned to any physical interface of the device. The device has at least two physical interfaces: Ethernet (eth) and radio (rf). Usually, the system is linked to

ISP's backbone networks via radio interface and ISP's backbone is built using private internets. So what is the physical interface to assign the public IP?

It may be assigned using alias name to any physical interfaces or to virtual interface null0.

```
ifconfig null0 123.1.1.1/32 up
```

More than that, sometimes one can avoid public IP assignment to physical interfaces at all. The procedure goal is to provide public IP accessibility from Internet. But this may be done using static routing. All packets routed to this public address will get into your LAN. Link with the physical interfaces is not necessary. NAT-module will perform conversion before packet forwarding - enough packets entering into the device.

If the provider gave you a small block of address (e.g. 123.1.1.0/30), you can assign the whole block on **null0** (e.g. "ifconfig null0 123.1.1.0/30") and use these addresses. For example, in this case you can use the first address 123.1.1.0 as an alias_address, and the rest - for the packets redirection on the local machines using **nat redirect_xxx** (see below) or for other public addresses for other private networks.

NAT module is designed in such a way so the original source and destination addresses are used (this is important when creating firewall rules, qm rules, ipstat analyzing). For example, when creating a Firewall rule, one should use local addresses for the private network. They will be shown in **ipstat** module also.

This command also sets the name of an access list (ACL) of your private networks, which require network address translation.

All packets with source addresses that are included into the **local_acl** list are considered as outgoing and are subject to translation. Exceptions are the packets going from local_acl to local_acl, and packets going from local_acl to the system own addresses. All these packets and the rest of the packets are considered as incoming and, if they are not reserse to the translated connections, pass through without being changed.

```
acl add $NAT net 192.168.1.0/24

nat local_acl $NAT 123.1.1.1
```

In this example we created a list with the only network 192.168.1.0/24 (your private network), referring to it in **local_acl** command and assigning 123.1.1.1 address as a public address for this network.

You can create several private networks having assigned different public addresses to each of them. Translation will be carried out independently.

In order to delete a record for the private network from the configuration, use "-" sign instead of a public address. For example:

```
nat local_acl $NAT -
nat alias_address 123.1.1.1
```

This command is obsolete. Use **local_acl** command.

```
nat maxlinks NUM
```

This command set the maximum number of supported connections. 1000 by default.

The system automatically observes all the connections and dynamically destroys all unnecessary connections according to their type and time of activity. However, when using different network scanners there is a possibility that current number of connections will increase enormously or until there is a free space in the RAM. Using this command one can avoid this situation to happen. In the case when the number of current connection exceeds the threshold set the system will put the warning into the system log and restrict new connection establishment until the situation becomes stable. When connections number will decrease the corresponding message will be put into the system log and a normal work will be resumed.

Generally, it is enough to run NAT.

```
nat enable
```

This command enables NAT-module to start NAT according to specified rules.

Example:

```
ifconfig null0 123.1.1.1/32 up
rip start# to start dynamic routing for public IP
acl add $NAT net 192.168.1.0/24
nat local_acl $NAT 123.1.1.1
nat enable
```

Done. One can start to check access from the LAN.

```
nat disable
```

Disables NAT.

```
nat same_ports yes|no
```

This command forces NAT-module to leave ports numbers in the modified packets as they are. If it is impossible then arbitrary port numbers will be used.

```
nat verbose yes|no
```

Enables diagnostic mode and prints modified packets into system log.

```
nat Proxy only yes|no
```

If enabled then NAT-module only forwards packet according to proxy_rule commands. Usual NAT not performed.

```
nat stat
```

Shows NAT statistics.

Packet redirection

NAT disadvantage is that local hosts are not accessible from Internet. Local hosts can establish outgoing connections but cannot serve incoming. This hinders starting Internet applications on local hosts. Simple solution is to redirect traffic from some ports to local hosts.

The below commands dedicated for creating redirection rules (**redirect_xxx** and **proxy_rule**). Multiple command execution with different arguments allowed. Commands are numbered when browsed using **config show**. This allows to delete not needed rules using **nat del XX** where XX is sequential number in the **config show** list.

```
nat redirect_port
```

The command comes with two flavours.

First type:

```
redirect_port  proto  localIP:localPORT[-localPORT]
   [aliasIP:]aliasPORT[-aliasPORT]
   [remoteIP[:remotePORT[-remotePORT]]]
```

Redirect incoming packets for specified port to other address and other port.

Argument **proto** may be **tcp**, **udp**, **ras** or **cs**.

In case of **ras** and **cs** address modification is performed according to H.323

TargetPORT - given port or port range on the system.

AliasPORT - destination port (or port numbers).

The port ranges **aliasPORT** and **targetPORT** may not coincide in numbers but should be of the same range.

If you are using several pairs of public address-private network, it is recommended to specify the exact public address.

Parameters **remoteIP** and **remotePORT** may be specified for more exact definition of incoming packets (packets only from specified source and port will be allowed). If **remotePORT** is not specified then its range should coincide with range of **targetPORT**.

```
nat redirect_port tcp 192.168.1.5:23  7777
```

In this example all incoming tcp connections to port 7777 will be redirected to host 192.168.1.5 port 23 (telnet).

```
nat redirect_port tcp 192.168.1.4:2300-2399
   123.1.1.2:3300-3399
```

All incoming tcp packets with targetPORT range 3300-3399 and destination address 123.1.1.2 will be redirected to 192.168.1.4. Port mapping is "1 to 1", i.e. 3300->2300, 3301->2301.

For example, IRC-server is running on client A and WEB-server is running on client B. Then in order to get it work, connections accepting on ports 6667(irc) and 80(web), should be redirected to the appropriate hosts:

```
nat redirect_port tcp 192.168.0.2:6667 6667

nat redirect_port tcp 192.168.0.3:80 80
```

Second type:

```
redirect_port  proto
   localIP:localPORT[,localIP:localPORT[,...]]

            [aliasIP:]aliasPORT

            [remoteIP[:remotePORT]]
```

Cyclic redirection of incoming packets to several destination addresses (lke redirect_address) for unform load distribution between them (**LSNAT**):

```
nat redirect_port tcp 192.168.1.2:80, 192.168.1.3:80
   123.1.1.2:80
```

In this case all requests to WEB-server 123.1.1.2 will be redirected to the LAN servers.

```
nat redirect_address local IP [,local IP,…] public IP
```

Redirects all incoming traffic directed to **publicIP** to **localIP**. If several **localIP** addresses specified then redirection will be done in round-robbin fashion.

```
nat redirect_address 192.168.1.2 192.1.1.1

nat redirect_address 192.168.1.3 192.1.1.2
```

In this case all traffic incoming to 192.1.1.1 will be redirected to the LAN address 192.168.1.2, and traffic incoming to 192.1.1.2 will be redirected to 192.168.1.3.

Address redirection makes sense when there are several IP-addresses on the same host. In this case NAT can assign to every LAN client its own external IP-address.

Then NAT transforms outgoing packets, changing IP-addresses to public external IP-addresses. For example, IP-addresses 128.1.1.1, 128.1.1.2, 128.1.1.3 belong to the gateway. 128.1.1.1 can be used as public gateway IP-address, and 128.1.1.2 and 128.1.1.3 will be redirected to LAN clients A and B:

```
nat redirect_address 192.168.1.2 128.1.1.2
nat redirect_address 192.168.1.3 128.1.1.3
```

```
redirect_proto proto localP [publicIP [remoteIP]]
```

Redirects all the incoming packets with specified protocol **proto** to the host with address **localIP**.

```
nat redirect_proto 47 192.168.1.2
```

If **publicIP** then used value of command **alias_address**.

```
nat default_h323 [yes|no]
```

Includes address modification according to H.323 stack for outgoing connections. Affects all incoming UDP packetsd destined for port 1719 and incoming TCP connections for port 1720. By default disabled.

CAUTION

Do not enable this option unless needed, because this will hinder NAT performance if not used in IP telephony applications.

```
nat h323_destination ras|cs remote_addr[:remote_port]
   [local_addr[:local_port]]
```

Enables to describe more specifically using of H.323 elements in the external network.

- **ras|cs** - H.323 stack layer specified for processing.
- **remote_addr** - address of external network, its connections will be processed.
- **remote_port** - port, its outgoing connections will be processed. If port not specified then used value 1719 for ras and value 1720 for cs.

- **local_addr** - LAN host address, its outgoing connections will be processed. If address not specified then any port connections will be processed.

- **local_port** - a port outgoing messages from which will be processed. If the port is not specified, the all connections from all ports are processed.

```
nat proxy_rule parameter value [parameter value]…
```

Redirection of outgoing packets. TCP packets outgoing from LAN to any address with specified port, redirected to specified server and port. Optionally initial destination address may be included into the packet using several ways. Command line consists of word pairs: key parameter and its value.

Allowed parameters:

type encode_ip_hdr | encode_tcp_stream | no_encode

If transparent gateway requires information of initial address and an access port of a new server, then it may be done in two following ways:

- If option **encode_ip_hdr** specified then original address and port are transmitted in extended IP header fields (IP option).

- If option **encode_tcp_stream** specified, then original port and address are transmitted in a packet before data start in format "DEST IP port".

port portnum

Only packets sent to specified port are processed.

server host[:portnum]

Mandatory parameter. Specifies server address and port for packet redirection. If port not specified then original destination port will be used.

proto tcp | udp

If specified then only packets with specified protocol will be processed.

src IP[/bits]

dst IP[/bits]

Non-mandatory parameter. Specifies source/destination net (subnet) for packet redirection.

Example:

```
nat proxy_rule proto tcp port 80 server 123.1.1.1:3128
```

In given example all outgoing LAN TCP packets destined for port 80 will be redirected to provider proxy server.

```
nat del rule_number
```

Deletes the rule numbered by **rule_number**.

4.15 Trapd Command (SNMP Trapd Support)

SNMP trapd support module

Syntax:

```
trapd [-]dstaddr x.x.x.x[:PORT]

trapd [[-]agent x.x.x.x]

trapd [[-]gateway xxxxxxxxxxxx|auto]

trapd type TYPENAME enable|disable

trapd start|stop
```

Description:

SNMP protocol allows a network agent to send asynchronous traps when some specific event occurs on the controlled device (object).

Trapd module performs a centralized information delivery from internal device subsystems to the configured SNMP server.

SNMP server address is set by "**trapd dstadd X.X.X.X**" command (UDP port 162). Agent's own address, which is set in SNMP-trap packet, is defined by "**trapd agent X.X.X.X**" command. 127.0.0.1 address by default. "**Trapd gateway X.X.X.X**" command defines gateway for traps. Trapd gateway automatic setting by **auto** parameter is also possible.

Example:

```
trapd dstaddr 192.168.1.1

trapd start
```

4.16 DHCP Server

4.16.1 DHCP Server Command Language

Commands used for configuration/review of current DHCP server state are entered using console or Telnet. Prefix command for WANFleX command interpreter is **dhcpd**.

Full command list (without prefix command):

Syntax:

```
add dscope <SCOPE_NAME> <INTERFACE|*> <START_IP> <END_IP>

add scope <SCOPE_NAME> <INTERFACE|*> <START_IP> <END_IP>

add virtual interface <GATEWAY>

clear

delete option <OPTION_NAME>

delete scope <SCOPE_NAME>

delete virtual interface <GATEWAY>

interface <INTERFACE> delete option <OPTION_NAME>

interface <INTERFACE> option <OPTION_NAME> <OPTION_VALUE>

interface <INTERFACE> reservation <CLIENT_ID> delete option
   <OPTION_NAME>

interface <INTERFACE> reservation

     <CLIENT_ID> option <OPTION_NAME> <OPTION_VALUE>

interface <INTERFACE|*> show boundhistory

interface <INTERFACE|*> show client <CLIENT_ID|*>

lock interface <INTERFACE>

notrace

option <OPTION_NAME> <OPTION_VALUE>

scope <SCOPE_NAME> add classid <CLIENT_CLASS_ID>

scope <SCOPE_NAME> add exclude <START_IP> <END_IP>

scope <SCOPE_NAME> add reservation <CLIENT_ID> <CLIENT_IP>

scope <SCOPE_NAME> delete classid <CLIENT_CLASS_ID>
```

```
scope <SCOPE_NAME> delete exclude <START_IP>
scope <SCOPE_NAME> delete option <OPTION_NAME>
scope <SCOPE_NAME> delete reservation <CLIENT_ID>
scope <SCOPE_NAME> interface <INTERFACE|*>
scope <SCOPE_NAME> option <OPTION_NAME> <OPTION_VALUE>
scope <SCOPE_NAME> reservation
    <CLIENT_ID> delete option <OPTION_NAME>

scope <SCOPE_NAME> reservation
     <CLIENT_ID> option <OPTION_NAME> <OPTION_VALUE>
scope <SCOPE_NAME> set range <START_IP> <END_IP>
scope <SCOPE_NAME|*> show declinehistory
show config
show interface <INTERFACE|*>
show options
show scope <NAME|*>
show unleases <SUBSTR|*>
show version
show xml
start
stop
trace
unlock interface <INTERFACE>
virtual interface <GATEWAY> add subnet <IP_ADDRESS>
   <SUBNET_MASK>
virtual interface <GATEWAY> delete subnet <IP_ADDRESS>
   <SUBNET_MASK>
```

Commands are not case-sensitive and can be shortened unless ambiguity appears.

For example, **dhcpd show scope *** command can be shorted to **dhcpd s s ***, in its turn **dhcpd show config** - to **dhcpd sh c**. The commands which change DHCP configuration (including "**stop**" and "**start**" commands) can be executed only by

administrator with super-user rights. Other commands can be executed by any user.

Trace|notrace options enables|disables writing DHCPD service information to system log.

Show xml shows DHCPD configuration in XML format.

In above command list parameters are put into <>. If parameter value contains spaces, this parameter must be put into quotes.

Example:

```
#2>dhcpd scope MSOFT add classid "MSFT 5.0"
```

or

```
#2>dhcpd add scope "Micro Soft" eth0 9.1.1.201 9.1.1.250
```

Attention! DHCP executes commands ONLY after its start:

```
dhcpd start
```

4.16.1.1 DHCP Client

DHCP protocol is used for (workstations and servers) TCP/IP network hosts connection parameters dynamic configuration. UDP/IP protocol is used as a transport protocol. Host which requests data for its network connection configuration (IP-address, subnet mask, default gateway etc) is called DHCP-client. IP-address is a basic configuration parameter. After client's start it sends a DHCP request over the network so it could get a lease of IP-address and other network parameters. For its identification in its request a client may use client identifier. In general case, client identifier is a binary set of bytes which is unique within a physical network segment to which a client is connected. If client does not provide an identifier, the server will accept client's MAC-address for network interface. Thus, in DHCP server a client is identified by its identifier and network interface from which server accepts client's requests (client's interface). Client's identifier (<CLIENT_ID> parameter in commands) is represented as ID:<identifier> or 01:<MAC-address of network adapter>.

Example:

ID:01:00:04:35:22:88:1D.

In its requests to the server, a client may indicate its class (class identifier). Class identifier is a string which defines one of client's properties which is common for a set of clients. For example, it can be client operating system's name.

4.16.1.2 Address Scope

Scope is a range of IP-addresses within which a server can assign addresses to its clients. Scopes are located in a configuration database of a server and are identified by names configured by server administrator when this scope was created. Scope is created by the following command:

Syntax:

```
dhcpd add scope <SCOPE_NAME> <INTERFACE|*> <START_IP>
   <END_IP>
```

here

- *SCOPE_NAME* - scope name. It is not case-sensitive and must be unique. If scope name contains spaces, server will automatically substitute them with "underscore" sign (_).

- *INTERFACE* - name of network interface with which this scope will be attached (allowed interface). If * is specified as interference, that means that this scope can be attached to all suitable network interfaces. Suitable network interface is an interface which contains a subnet of IP-addresses (aliases) that includes starting and ending IP-addresses of the scope.

- *START_IP* and *END_IP* - starting and ending IP-addresses of the scope correspondingly. When attaching to network interface, it is checked if a range of this scope does not intersect (and is not included) within another scope that might be attached to this interface. When IP-addresses are assigned to clients, only those scopes can be used which are connected to the same network interface as a client.

In any case, if a scope cannot be attached, it is not deleted.

Add dscope command creates temporary (for 1 dhcpd session) range of IP-addresses that are not shown in the configuration output.

Example:

```
#2> dhcpd add scope MSOFT eth0  192.168.177.20 192.168.177.22


[eth0] <192.168.177.12> (MSOFT):
  192.168.177.20-192.168.177.22   Scope attached
```

```
OK
```

In the example, we created a scope with MSOFT as a name and for suitable interface **eth0**.

```
#2> dhcpd add scope new * 10.12.12.30 10.12.12.50
WRN: Scope created, but not attached.
```

Here a scope with **new** name was created to be attached to any suitable interface. A scope was successfully created but could not find a suitable interface to be attached to.

In order to change a range of addresses of existing scope one can use the following command.

Syntax:

dhcpd scope <SCOPE_NAME> **set range** <START_IP> <END_IP>

where

- *SCOPE_NAME* - scope name which range we change
- *START_IP* and *END_IP* - new starting and ending IP-addresses of a scope correspondingly

In order to change an interface for the scope one can use the following command.

Syntax:

scope <SCOPE_NAME> **interface** <INTERFACE|*>

where

- *SCOPE_NAME* - scope name which interface we change
- *INTERFACE* - name of the network interface to which a scope is attached to. If a system does not have an interface with specified name or a system cannot attach this scope to specified interface, the scope will be immediately detached. This feature can be used for temporary shutdown of one of the scopes.

Example:

```
#2> dhcpd scope OTHER interface -eth0
[eth0] <192.168.177.12> (OTHER):
```

```
 192.168.177.10-192.168.177.19   Scope detached
OK
```

Thus, we detached **OTHER** scope. In order to attach it again we need the following command:

```
#2> dhcpd scope OTHER interface eth0 (or *)
[eth0] <192.168.177.12> (OTHER):
192.168.177.10-192.168.177.19 Scope attached
OK
```

One can set up **excludes** into scope range of addresses. Excludes are range of addresses which belong to the scope but are not given to DHCP server clients. The following command should be used:

Syntax:

dhcpd scope <SCOPE_NAME> **add exclude** <START_IP> <END_IP>

where

- *SCOPE_NAME* - scope name to which we add excludes
- *START_IP* and *END_IP* - starting and ending addresses of an exclude. Exclude's range should not intersect (or belong) with any of previous excludes assigned to this scope. Exclude's range should belong to the scope. To delete an exclude, one should do the following:

Syntax:

dhcpd scope <SCOPE_NAME> **delete exclude** <START_IP>

This command's parameters are identical to the command for exclude configuration besides the fact that here one can specify only starting address of an exclude to be deleted.

NOTE

When executing command **dhcpd scope <SCOPE_NAME> set range <START_IP> <END_IP>**, excludes which were created before range changing and which stop satisfying conditions described above, will be deleted automatically.

4.16.1.3 Clients class filter (CLASSID)

Scope of addresses has clients class filter. If a client in its request submits its class, a server is able to give an IP-address only from those scopes which are

connected to client's interface and which have client's class specified in their class filter. Class filter is a set of **client vendor class id** from which it is allowed to give a lease for IP-addresses from the scope. In order to create a class filter for a scope, one should add one or more **client vendor class id**. To add a client vendor class id to the scope, the following command is used:

Syntax:

scope <SCOPE_NAME> **add classid** <CLIENT_CLASS_ID>

where

- *SCOPE_NAME* - name of the scope to which client vendor class id is added (CLIENT_CLASS_ID)

- *CLIENT_CLASS_ID* - a set of characters of variable length (up to 255 characters). If this parameter contains spaces it should be specified in quotes. This <CLIENT_CLASS_ID> is compared to what client submits when requests for IP-address lease. If client submitted a class which does not present in any of scope's filters or a client did not submit any class name, only scopes with no class filters can be used for IP-address lease.

In order to delete a class from the filter, the following command is used:

Syntax:

scope <SCOPE_NAME> **delete classid** <CLIENT_CLASS_ID>

4.16.1.4 Network interfaces (INTERFACE)

Network interface - physical or VLAN network adaptor registered in OS WANFleX core. After its start, the server automatically detects all network interfaces which are suitable for serving DHCP clients. Suitable interface is an interface connected to a multiple-access network with broadcast support (including VLAN support). In server database each interface is identified by its name which was assigned to it while registration in WANFleX OS core. In order to review all interfaces, use the following command:

Syntax:

show interface <INTERFACE|*>

where

- *INTERFACE* - network interface name which information is required. If * is specified instead of interface name, all interfaces' information is printed. Command output is a structured list:

Example:

```
#2> dhcpd show interface *
>INTERFACES
[eth0] UP
 <SUBNET> 9.1.1.100/255.255.255.0
        <SCOPE> (PHONES) 9.1.1.151 - 9.1.1.200
 <SUBNET> 192.168.177.12/255.255.255.0
        <SCOPE> (OTHER) 192.168.177.10 - 192.168.177.19
        <SCOPE> (MSOFT) 192.168.177.20 - 192.168.177.22
[vlan0] DOWN
 <SUBNET> 192.168.178.1/255.255.255.0
OK
```

From this example it is seen that two network interfaces (**eth0** and **vlan0**) are served. **eth0** is turned on (UP) and it has two IP-subnets. To one of the subnets we can see a scope PHONES connected. To another subnet: OTHER and MSOFT. None of the scopes can be connected to **vlan0** interface as it was turned off by the administrator (DOWN).

If required it is possible to lock one or several interfaces - in this case they cannot be used. Command is the following:

Syntax:

```
lock interface <INTERFACE>
```

where

- *<INTERFACE>* - interface name. When locking interface, all attached scopes will be detached. Other scopes cannot be attached to the interface while it is locked.

Example:

```
#2> dhcpd show interface *
>INTERFACES
[eth0] UP
 <SUBNET> 9.1.1.100/255.255.255.0
        <SCOPE> (PHONES) 9.1.1.151 - 9.1.1.200
```

```
 <SUBNET> 192.168.177.12/255.255.255.0
        <SCOPE> (OTHER) 192.168.177.10 - 192.168.177.19
        <SCOPE> (MSOFT) 192.168.177.20 - 192.168.177.22
[vlan0] DOWN
 <SUBNET> 192.168.178.1/255.255.255.0
OK
```

In this example, the DHCP server has two interfaces: eth0 and vlan0. vlan0 interfaces was turned down by WANFleX command: **ifconfig vlan0 down**. Eth0 is turned on and we see three scopes attached to it: phones, other and msoft. PHONES is attached to 9.1.1.100/255.255.255.0 subnet, two others - to 192.168.177.12/255.255.255.0 subnet. Imagine that we want lock eth0 interface:

Example:

```
#2> dhcpd lock interface eth0
[eth0] <9.1.1.100> (PHONES):
  9.1.1.151-9.1.1.200   Scope detached
[eth0] <192.168.177.12> (OTHER):
  192.168.177.10-192.168.177.19   Scope detached
[eth0] <192.168.177.12> (MSOFT):
  192.168.177.20-192.168.177.22   Scope detached
OK
```

After locking, let us see interfaces information again:

```
#2> dhcpd show interface *
>INTERFACES
[eth0] UP LOCKED
 <SUBNET> 9.1.1.100/255.255.255.0
 <SUBNET> 192.168.177.12/255.255.255.0
[vlan0] DOWN
 <SUBNET> 192.168.178.1/255.255.255.0
OK
```

Now eth0 interface is locked and it had all his scopes detached.

Interface can be unlocked:

Syntax:

```
dhcpd unlock interface <INTERFACE>
```

Example:

```
#2> dhcpd unlock interface eth0
[eth0] <192.168.177.12> (MSOFT):
  192.168.177.20-192.168.177.22   Scope attached
[eth0] <192.168.177.12> (OTHER):
  192.168.177.10-192.168.177.19   Scope attached
[eth0] <9.1.1.100> (PHONES):
  9.1.1.151-9.1.1.200   Scope attached
OK
#2> dhcpd show interface *
>INTERFACES
[eth0] UP
 <SUBNET> 9.1.1.100/255.255.255.0
        <SCOPE> (PHONES) 9.1.1.151 - 9.1.1.200
 <SUBNET> 192.168.177.12/255.255.255.0
        <SCOPE> (OTHER) 192.168.177.10 - 192.168.177.19
        <SCOPE> (MSOFT) 192.168.177.20 - 192.168.177.22
[vlan0] DOWN
 <SUBNET> 192.168.178.1/255.255.255.0
OK
```

4.16.1.5 Scope reservation

The target of scope reservation is to reserve an IP-address for a specific client. The command is the following:

Syntax:

dhcpd scope <SCOPE_NAME> **add reservation** <CLIENT_ID> <CLIENT_IP>

where

- **SCOPE_NAME** - name of the scope to which reservation is added,

- **CLIENT_ID** - client identifier,
- **CLIENT_IP** - IP-address which will be given to this client. Scope reservations are saved in configuration database of the server and are identified by scope name and client's identifier.

Example:

```
#2>dhcpd scope PHONES add reservation ID:01:00:04:35:00:22:23
   9.1.1.170

OK
```

If reservation is no more required, you can delete it:

Syntax:

```
dhcpd scope <SCOPE_NAME> delete reservation <CLIENT_ID>
```

4.16.1.6 Configuration options

Configuration options are parameters which clients might request from the server for more precise host configuration. These parameters are *Address Time*, *Router*, *NTP Servers* etc. Clients may request a different set of these parameters. The parameters are only sent when a client included them in its request and only when server knows the value of the parameter. Divisions and values of the parameters are defined while DHCP server configuration. Divisions can be defined for the following purposes:

1. Scope reservation. Options values from this division will be given to the client of this reservation.
2. Interface reservation. Options are sent if requested option's value is not in scope's reservation divisions.
3. Scope. Option values from this division can be sent to the client who received an address lease from this scope only if the option requested by the client is not in scope's or interface's reservation division.
4. Interface. Sent to the client which received a lease from one of the scopes which is attached to the interface (and the value of the requested option was not in scope's reservation, in the scope itself and in interface's reservation).
5. Server. Sent to clients which received a lease from one of the scopes (if the value of the option was not in all divisions listed above)? Meaning of the division - default value.

If option's value does not exist in all divisions, client does not receive anything from the server. Two exceptions are possible:

- *Address Time* - the value of this parameter is ALWAYS sent to the client. If this value is not specified in all divisions, the client receives a default value of 120 (lease time - 2 minutes).

- *Subnet Mask* - the value of this parameter is ALWAYS sent to the client. The value of this option is automatically determined by the server and it cannot be defined in options divisions while server configuration. The value of the subnet mask for the client always equals subnet mask of the interface to which the scope is attached (this scope gave a lease to the client)

DHCP configuration options (overall table) is available using the following link: **http://www.iana.org/assignments/bootp-dhcp-parameters**

To define a set of options, DHCP server has special commands for each division. These commands have parameters, which are inputted in a common way (for all divisions):

OPTION_NAME - name of the option (see the link for the table above). If option name has spaces, they must be substituted with "_" sign. Option name is not case-sensitive.

OPTION_VALUE - value of the option. Input format depends on the purpose of the option and is divided into three categories by DHCP server:

1. Symbolic. A string (e.g. for *Bootfile-Name option*). If this option's value has spaces, the option value should be put in quotes.
2. Binary. One or several decimal numbers. If several numbers should be specified, they are separated by commas. Options examples: *Address Time*, *Time Offset*.
3. IP-address. One or several values - IP-addresses. Several IP-addresses are separated by commas.

Commands for defining/adding options for different divisions:

1. Scope reservation division

Syntax:

```
dhcpd scope <SCOPE_NAME> reservation
      <CLIENT_ID> option <OPTION_NAME> <OPTION_VALUE>
```

where

- **SCOPE_NAME** - scope name for which reservation one need to define an option value.

- **CLIENT_ID** - reservation client identifier. If this option with the same name was defined, the value will be changed to the one specified in this command.

2 Interfaces reservations division

Syntax:

```
dhcpd interface <INTERFACE> reservation
    <CLIENT_ID> option <OPTION_NAME> <OPTION_VALUE>
```

where

- **INTERFACE** - name of the interface where client's (CLIENT_ID) reservation is created. If this interface did not have a reservation for this client, this command will automatically create this reservation and will add it to the options set.

Interfaces reservations are required for specific settings for the client no matter from what scope the client is getting his address lease. Interface reservation is different from scope reservation in two parameters:

- *Does not define a fixed IP-address for the client.* Thus it takes for the server to dynamically define from which scope and which IP-address is to be given to the client.

- *Allows changing client's class.* If *Class ID* option is defined for the interfaces reservation, the class will be changed for the option's value when a client from this reservation sends a request. It becomes necessary when DHCP client does not send its class.

Creating interface reservation does not contradict with scope reservation for the same client.

3 Scope divisions

Syntax:

```
dhcpd scope <SCOPE_NAME>
    option <OPTION_NAME> <OPTION_VALUE>
```

4 Interface divisions

Syntax:

```
dhcpd interface <INTERFACE>
   option <OPTION_NAME> <OPTION_VALUE>
```

5 Server divisions

Syntax:

```
dhcpd option <OPTION_NAME> <OPTION_VALUE>
```

Of course, there is a set of commands which delete all of these options from the divisions:

Syntax:

```
dhcpd scope <SCOPE_NAME>
     reservation <CLIENT_ID> delete option <OPTION_NAME>
dhcpd scope <SCOPE_NAME> delete option <OPTION_NAME>
dhcpd interface <INTERFACE>
     reservation <CLIENT_ID> delete option <OPTION_NAME>
dhcpd interface <INTERFACE> delete option <OPTION_NAME>
dhcpd delete option <OPTION_NAME>
```

One should pay a great deal of attention to the deletion of interfaces reservation division options. If, after deletion, it turns out that options set for this reservation is empty, the interface reservation will be deleted automatically.

Not all of the options can be defined in any division. Apart from Subnet Mask (was described above), there are options which can be defined for some particular divisions.

Example:

```
#1> dhcpd scope phones option class_id "TestClass"
ERR: This option cannot contain in the given division.
```

Moreover, there is a set of service options which although are included into a summary table, they do not act as configuration parameters but act as service parameters. The list of service options of DHCP server looks as follows:

- Subnet Mask
- Address Request

- Overload
- DHCP Msg Type
- DHCP Server Id
- Parameter List
- DHCP Message
- DHCP Max Msg Size
- Client Id

If you attempt to add one of these options to any division, the server will report an error: **ERR: This option cannot contain in the given division.**

To control options which were requested by the client and given to him, one can use the following command:

Syntax:

```
dhcpd interface <INTERFACE|*> show client <CLIENT_ID|*>
```

where

- **INTERFACE** - name of a network interface which information is requested
- **CLIENT_ID** - client's identifier, which information is requested. Instead of interface name one can specify "*": this will print information for all clients and interfaces. Instead of client's identifier it is permitted to specify "*": this will print information about all clients for the specified interface. The information is shown only for clients with given address lease from one of the scopes which is attached to the specified interface.

Example:

```
#2> dhcpd interface * show client *
>INTERFACES CLIENTS
--------- [eth0] ---------
(IPHONES) <CLIENT> ID:01:00:04:35:00:22:24 " IP_PHONE"
   'Unknown node' 192.168.0.101   <BOUND>    since 25/04/2005
   11:32:57
```

```
SUPPLIED OPTIONS:

#1       .  .  .  .  . DF Subnet Mask
   255.255.255.0

#2       .  .  .  .  .  . Time Offset              <not
   supplied>

#3       .  .  S  .  .  . Router                   192.168.0.1

#7       .  .  .  .  .  . Log Server               <not
   supplied>

#42      .  .  S  .  .  . NTP Servers              192.168.0.1

#230     .  .  S  .  .  . H323 GK ADDRESS          192.168.0.1

#231     . IR  .  .  .  . H323 LOGIN ALIAS         IWPhone/V.
   Pupkin/101

#232     .  .  .  .  .  . H323 GK ID               <not
   supplied>
```

Here, the list of client's supplied options consists of records (strings) which contain a number (#<N>) of a supplied option, a map of server's divisions from which this option was supplied to a client (if was supplied), name of the option and its value. If a requested option was not defined in any of server's divisions, it is displayed as <not supplied> in the list. On the map the divisions are displayed using the following indication:

1. SR - scope reservation division
2. IR - interface reservation division
3. S - scope reservation
4. I - client's interface division
5. SV - server's division

Moreover, the options which were requested by clients and supplied to them but which were not defined in any division (e.g. Subnet Mask) are marked as DF.

4.16.1.7 Address Time

Any IP-address lease is limited by the time specified in *Address Time* option. If a client which was given a lease does not extend it within *Address Time* period, the server will cancel the lease. The value of this time may be defined by the client but it should not exceed its maximal value. The maximal time of a lease is set up in *Address Time* of one of the divisions to which this client is applied. If a server does not have this option defined, the maximal time will be set to 120 seconds. In case

if a client does not request *Address Time* parameter, the server will give a lease for a maximal time according to the scheme described above.

A client which received a lease, confirms it periodically. The periodicity is usually equal to the half of *Address Time*. As an acknowledgement to the lease prolongation the server resends configuration parameters (options). Thus, if during the lease some of the options were changed in the server (or division to which this client was applied) the client will learn it in the moment of lease prolongation.

If after lease expiration the client does not confirm it, the scope cancels the lease. If the client is not a scope reservation client, the scope will mark the IP-address of this lease as "conditionally free". On scope state output (dhcpd show scope *) this state will be marked as <OBIND>. Thus, with other addresses available for lease, the scope will not give <OBIND> addresses for new clients. If during 24 hours from the moment of lease expiration the client will request for a lease again, the server will give him the same IP-address.

```
#1> dhcpd show scope MSOFT

>SCOPES:

(MSOFT)          192.168.177.20  - 192.168.177.22  [eth0]
   ATTACHED [eth0] <192.168.177.12>/255.255.255.0

 <CLIENT CLASS IDs>: "BRI_GATEWAY" "MSFT 5.0"

 <CLIENT> ID:01:00:C0:DF:10:AF:69 "MSFT 5.0"      'wad     '
   192.168.177.20  <BOUND>    since 01/01/2003 01:01:14

 <O_BIND> ID:01:00:0F:EA:05:29:C6 "MSFT 5.0"     'win2k3sbs'
   192.168.177.21  <OBIND>

 <FREE RANGE>   192.168.177.22  - 192.168.177.22   =1

OK
```

At the same time, the scope writes down the parameters of expired lease into a special database (boundhistory).

```
#1> dhcpd interface eth0 show boundhistory

[eth0]

>BOUND_HISTORY 1

(MSOFT) ID:01:00:0F:EA:05:29:C6 BOUND=192.168.177.21
   until 02/01/2003 13:25:37

OK
```

The information about expired leases is saved in the database during 24 hours. After 24 hours the record is automatically deleted from the database, and the IP-address becomes a free address (after being <OBIND>).

The server will use <OBIND> addresses for other clients if all the scopes (which suit new clients) ran out of free addresses. The server will use the oldest records in "boundhistory" in the first turn.

The server will also cancel an address lease after a client's corresponding request.

4.16.1.8 Admissibility check for IP-addresses lease

The check is made in order to avoid IP-addresses conflicts. After the server detected the IP-address as being free, it will perform an admissibility check prior to IP-address lease to the client. In other words, the server makes sure that this IP-address is not occupied by any host (except, may be, for the target client itself) on the client's interface. The server makes ARP-requests on the client's interface. If no one answered the request (may be except for the target client), the IP-address will be given for a lease.

This check is performed in any case except for case of virtual interfaces when the check is a client's responsibility.

If IP-addresses conflict is detected, this IP-address will not be given for a lease. The server will attempt to give a next free IP-address. If, eventually, there is no free IP-address left, the server looks into *boundhistory* for the client's interface. If this step failed, the server puts this client into a database of unleases.

4.16.1.9 Unleases

Clients to which DHCP server failed to give an IP-address for a lease are put to a special list - unleases. The records in this list are saved for 15 minutes if a client does not repeat an attempt to get a lease. Each record in the list consists of the following fields:

1. Name of a network interface from which a client's request for a lease was received (client's interface).
2. Client's identifier
3. Client's class identifier
4. Host name

To view the list, use the following command:

Syntax:

```
dhcpd show unleases <SUBSTR|*>
```

where

- **SUBSTR** - a substring for a partial list view. When executing a command the server will print only those records which fields contain the substring (one of the fields). Substring is case-sensitive. If * is specified as a substring the full list is printed.

Example:

```
#1> dhcpd show unleases *
>UNLEASES 1
eth0    ID:01:00:C0:DF:10:AF:69 "MSFT 5.0"      wad
OK
```

4.16.1.10 Virtual interfaces

After their start, DHCP clients send broadcast request in order to get an IP-address lease. As a client at this time does not yet have an IP-address the server also uses broadcast packets to communicate with a client. It is known that broadcast packets are not routed and, thus, the dialog between DHCP server and DHCP client can occur only within one network (physical network). If DHCP server is connected to another network, the direct dialog cannot take place. However, the device which logically connects two networks with DHCP client and DHCP server can have a special software running - DHCP Relay Agent (DRA). DRA retranslates DHCP packets (including broadcast packets) from DHCP clients to DHCP server and back. Data exchange between DRA and DHCP server is performed using unicast packets only. Thus, DRA and DHCP must know each other's IP-addresses starting from their configuration stage. For this purpose DHCP server has *virtual interfaces*. In fact DHCP-server virtual interface is a physical network interface placed in DRA. As DHCP does not know this interfaces subnets sets, one should specify these subnets while virtual interfaces configuration.

To create virtual interface, use the command:

Syntax:

```
dhcpd add virtual interface <GATEWAY>
```

where

- **GATEWAY** - IP-address of DRA which has a corresponding physical interface. After executing this command, one more interface is created in server's configuration with a name formed from DRA's IP-address: v.GATEWAY. Example: v.192.168.177.81

Example:

```
#1> dhcpd add virtual interface 192.168.177.81
[v.192.168.177.81]
  Virtual interface v.192.168.177.81 added
OK
#1> dhcpd show interface *
>INTERFACES
[eth0] UP
 <SUBNET> 9.1.1.100/255.255.255.0
        <SCOPE> (PHONES) 9.1.1.151 - 9.1.1.200
 <SUBNET> 192.168.177.12/255.255.255.0
        <SCOPE> (MSOFT) 192.168.177.20 - 192.168.177.50
 <SUBNET> 192.168.15.55/255.255.255.0
 <RESERVATION>  for ID:01:00:05:90:02:1F:C8
        <OPTION>        Class_Id        "Swissvoice"
[vlan0] DOWN
 <SUBNET> 192.168.178.1/255.255.255.0
>VIRTUAL INTERFACES
[v.192.168.177.81] UP
OK
```

In server's configuration we can observe one more interface with v.192.168.177.81 name. Working with this interface is no different from other interfaces. However, before a scope is attached to it, one should configure a set of subnets. The following command can be used:

Syntax:

```
dhcpd virtual interface <GATEWAY> add subnet <IP_ADDRESS>
   <SUBNET_MASK>
```

where

- **GATEWAY** - IP-address of DRA which corresponds to the virtual interface
- **IP_ADDRESS** - IP-address which DRA has for this subnet

- **SUBNET_MASK** - subnet mask

Example:

```
#1> dhcpd virtual interface 192.168.177.81
       add subnet 192.168.188.1 255.255.255.0
[v.192.168.177.81]  Subnet added
                  192.168.188.1/255.255.255.0
OK
#1> dhcpd show interface *
>INTERFACES
[eth0] UP
 <SUBNET> 9.1.1.100/255.255.255.0
        <SCOPE> (PHONES) 9.1.1.151 - 9.1.1.200
 <SUBNET> 192.168.177.12/255.255.255.0
        <SCOPE> (MSOFT) 192.168.177.20 - 192.168.177.50
 <SUBNET> 192.168.15.55/255.255.255.0
 <RESERVATION>  for ID:01:00:05:90:02:1F:C8
        <OPTION>        Class_Id        "Swissvoice"
[vlan0] DOWN
 <SUBNET> 192.168.178.1/255.255.255.0
>VIRTUAL INTERFACES
[v.192.168.177.81] UP
 <SUBNET> 192.168.188.1/255.255.255.0
OK
```

After that, we can create a scope of addresses from which a DHCP server can give a lease to the clients to which a DRA has an access.

Example:

```
#1> dhcpd add scope VIRTUAL_TEST
     v.192.168.177.81 192.168.188.20 192.168.188.50
[v.192.168.177.81] <192.168.188.1> (VIRTUAL_TEST):
    192.168.188.20-192.168.188.50   Scope attached
```

```
OK
#1> dhcpd show interface v.192.168.177.81
>VIRTUAL INTERFACES
[v.192.168.177.81] UP
 <SUBNET> 192.168.188.1/255.255.255.0
        <SCOPE> (VIRTUAL_TEST)
           192.168.188.20 - 192.168.188.50
OK
#1> dhcpd show scope virtual_test
>SCOPES:
(VIRTUAL_TEST)  192.168.188.20  - 192.168.188.50
   [v.192.168.177.81] ATTACHED [v.192.168.177.81]
   <192.168.188.1>/255.255.255.0
 <FREE RANGE>   192.168.188.20  - 192.168.188.50   =31

OK
```

You can delete a subnet from virtual interface's list using the following command:

Syntax:

```
dhcpd virtual interface <GATEWAY>
      delete subnet <IP_ADDRESS> <SUBNET_MASK>
```

Example:

```
#1> dhcpd virtual interface 192.168.177.81
      delete subnet 192.168.188.1 255.255.255.0
[v.192.168.177.81] <192.168.188.1> (VIRTUAL_TEST):
      192.168.188.20-192.168.188.50   Scope detached
[v.192.168.177.81]  Subnet dropped
      192.168.188.1/255.255.255.0
OK
#1> dhcpd show scope virtual_test
>SCOPES:
```

```
(VIRTUAL_TEST)  192.168.188.20  - 192.168.188.50
   [v.192.168.177.81]


OK
```

As we deleted a subnet to which a scope was connected, the scope will be detached automatically. This scope will stay detached until an appropriate subnet is configured for v.192.168.177.81 virtual interface.

DHCP server configuration cleanup

In order to clean DHCP server configuration, it first should be stopped by dhcp stop command. After that, the configuration can be cleaned:

```
dhcpd clear
```

4.17 DHCP relay. dhcpr Command

4.17.1 General Description

For DHCP protocol regular work, the server and the hosts that get the service should be allocated within one network segment - no routers should be placed in between. If the network consists of several segments, each segment should have its own DHCP server as routers block broadcast packets. One of the alternatives to this solution is installing in each segment that does not have the server DHCP Relay Agent which forwards the requests from network hosts to DHCP server. Some routers may also have a function of DHCP Relay.

Syntax:

```
dhcpr [add]|delete SERVERIP

dhcpr (flush|trace|notrace)

dhcpr (lock|unlock) INTERFACE

dhcpr (info|noinfo)

dhcpr (start|stop)
```

4.17.2 Commands Description

4.17.2.1 Start / Stop of DHCP Relay

Syntax:

```
dhcpr {start | stop}
```

This command starts / stops DHCP relay.

Example:

```
dhcpr start
```

4.17.2.2 DHCP servers listing

Syntax:

```
dhcpr [add]|delete SERVERIP
```

This command adds / deletes DHCP servers to the list for which client's requests forwarding will be made.

Example:

```
dhcpr add 125.12.100.12
```

```
dhcpr 125.12.100.13

dhcpr delete 125.12.100.12
```

4.17.2.3 Interface blocking

By default, DHCP Relay accepts client's requests from all network interfaces of Ethernet type. If one of the interfaces needs to be blocked not to forward requests from it, a special command should be used.

Syntax:

```
dhcpr (lock|unlock) INTERFACE
```

INTERFACE - a name of one or several (separated by spaces) interfaces.

Example:

```
dhcr lock eth0
```

4.17.2.4 Using "DHCP Relay agent information" option

In order to identify client's interface when receiving server's replies, the relay can use a special DHCP option which he appends to the client's request packet while relaying. Not all of DHCP server support this capability. DHCP Relay has this option turned off by default. A special command can be used to turn this feature on.

Syntax:

```
dhcpr (info|noinfo)
```

Example:

```
dhcpr info
```

4.18 DHCP Client. dhcpc Command

4.18.1 General Description

DHCP client is used for automatic retrieving of different parameters from DHCP server for one or several unit's network interfaces. Among the parameters are IP-address, network mask, default gateway etc.

DHCP client management is implemented via **dhcpc** command.

Syntax:

```
dhcpc [options] [IFNAME] [commands]
```

IFNAME - name of the network interface to which **options** and **commands** are referred.

4.18.2 Options

Options define working parameters of DHCP client on a corresponding interface, or these options defaults if no interface name is specified. For each option special values can be specified: *none* and *default*. Option value *none* means this parameter absence for this interface even though default value of this parameter exists. Option value *default* means the absence of a specific parameter value (meaning that only default option exists). With this, default parameter value is applied if specified. *Default* option value is not displayed in DHCP client configuration.

- *-l (none|default|$ACLNAME|acl:ACLNAME)* - sets the list of IP-addresses of DHCP servers from which the client is permitted to receive parameters. Here, ACLNAME - the name of access control list (see **acl** command). If specified list is not configured in the system (this acl does not exist), DHCP client will be able to receive parameters from any DHCP server.

- *-k (none|default|key:KEYVALUE)* - sets authorization key. DHCP authorization is in accordance with "*RFC 3118 - Authentication for DHCP Messages*".

- *-a (none|default|NUMBER)* - sets the number of repeated *arp* requests which sends DHCP client after getting a lease of IP-address from DHCP server. In accordance with DHCP, the client is obliged to check received IP-address if there are any other network devices with the same IP-address. For higher reliability, DHCP client sends a series of such request with ¼ second interval. If *arp* requests number is not specified for all of the interfaces (including absence of default value for this parameter), DHCP client sends 16 requests.

- *-t (on|off)* - This option turns on/off sending debug information to the system log. The option is not attached to any specific interface.

4.18.3 Commands

- *start* - starts DHCP client on a specified interface
- *stop* - stops DHCP client on a specified interface
- *delete* - stops DHCP client on a specified interface and clears all the options.
- *dump* - shows current status of DHCP client.

4.18.4 Examples

```
dhcpc -a 5

dhcpc -l $DHCP_SERVERS eth0 start

dhcpc -a none -k key:qwerty  rf5.0 start
```

This configuration sets the number for ARP requests of 5. For eth0 interface the list of allowed DHCP servers is specified in DHCP_SERVERS ACL. The client is started for eth0 interface. For rf5.0 interface none option is set for the number of ARP requests. Thus, rf5.0 will send 16 ARP requests. Also, DHCP client on rf5.0 interface will use "qwerty" as authorization key.

```
dhcpc dump
```

The command prints current status of DHCP client.

```
ID  I-face   IP address/mask   Gateway address    Server ID
   Lease exp.

== ======== ================== =============== ===

 0   eth0   192.168.61.29/26    192.168.61.1    192.168.61.1
   000:35:16

 1   rf5.0  ------------------ ---------------
```

Here, clients are started on eth0 and rf5.0 interfaces.

For eth0 interface DHCP client obtained a lease for 192.168.61.26 IP-address with 26 bits network mask length from 192.168.61.1 DHCP server. The lease expires in 35 minutes and 16 seconds.

4.19 DNS Client

DNS client module allows using DNS services on a device. To start and mange DNS client use "**dnsclient**" command:

```
dnsclient [options] [command]
  where commands are:
    start
    stop
  where options are:
    -domain={name}
    -server={address}
```

Start/stop commands starts/stops DNS service.

Available options:

- **-domain={name}** - sets local domain name
- **-server={address}** - sets IP address (in dot notation) of a name server. Several name servers can be specified by repeating this option.

4.20 Nslookup

This command allows knowing host name by its IP-address and vice versa.

Command syntax:

```
nslookup {name|ip}
```

Where **name/ip** parameter defines name or IP-address of the host.